

SCIENTIFIC AGRICULTURE

Vol. XIII.

MAY, 1933

No. 9

SOME FURTHER STUDIES ON THE ETIOLOGY OF BOVINE¹ *HAEMATURIA VESICALIS* (RED WATER) IN BRITISH COLUMBIA¹

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[Received for publication October 17, 1932]

Haematuria vesicalis (35, 36) or Red Water (47), is also variously known as Stallrot der Rinder (35), Hamaturie chronique des bovidés (35), Chronic Haematuria (16, 17, 30, 42), Enzootic Haematuria (20, 30), Chronique Haemorrhagic Cystitis (10, 30), Vesical Haematuria (30) and Bovine Haematuria (26); these are all descriptive names for a specific disease which occurs in adult cattle and is distinctively characterized by the presence of red blood corpuscles in the urine. This blood apparently originates from lesions of the mucous membrane of the bladder. It would appear, in uncomplicated cases, that the primary pathological conditions are almost entirely confined to this organ (8, 18, 24, 40), and that the frequent passing of bloody urine, which may occur intermittently or for prolonged periods, is a secondary condition. This loss of blood leads to anaemia and a progressive course of emaciation which finally results in the death of the affected animal. The colloquial name of "Red Water" has been given to this disease, as well as several others, on account of the presence of blood in the urine. The symptoms, course and anatomical changes have been clearly and completely defined by Hoare (30), Hutyra and Marek (35), Hadwen (25, 26), and Kalkus *et al* (40).

The disease occurs in many countries, and is a source of considerable loss in certain fairly well defined local areas under similar agricultural conditions. In Europe it has been recognized for nearly a century, and is referred to by Anderson (1842) (2), Hubner (1842) (34), Vaes (1843) (62), Vigney (1845) (7); it has been known for fifty years or more in Australia, and definite attention was drawn to it by T. H. Williams (63) in 1894. It has been investigated and recorded within the last quarter of a century in New South Wales by J. B. Cleland (13, 14), in 1911; in Ireland by Craig and Kehoe (1917) (17); also in England, Wales and Scotland (18); in New Zealand by J. Kerrigan (1925) (42); in Canada in 1907 by Bowhill (56); by Kalkus (1913) (40) in Washington, U.S.A.; by Case (11) in Hawaii (1911) and by Kearney (41) in Africa in 1912.

Many theories have been advanced as to its cause, and several curative treatments suggested, but none, so far, entirely satisfactory. The consensus of opinion of recent investigators, McKee and McKee (47), Grauer (24),

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Bruce (7), Craig (18), Dickinson and Bull (20), favours the suggestion that the disease is probably due to faulty nutritional conditions. It seems generally established that the habitat of this disease is high bench land, growing bush or trees, which has recently been brought under cultivation for pastures and other purposes, with possibly adjacent bush lands. The soil, unless thoroughly fertilized and cultivated after being broken is usually sour or acid in nature.

Local conditions of the affected farms, in the Fraser Valley area, British Columbia, conform to those found in other parts of the world where the disease is, or was, prevalent. The altitude at which Red Water farms occur appears to be from 40 feet to 350 feet above sea level.

Climatic conditions in the local affected area, based upon the 1930 report on climate of British Columbia (19), indicate that the climate of the affected area has a mild winter and a cool summer with a moderate annual precipitation, showing a yearly average precipitation of 53.81 inches, with 1627.5 hours of bright sunshine per year, and a mean monthly temperature of 49°F., within a range of 94°F. and 8°F. The temperatures above the average occur within the period between April and October; the highest hours of sunshine are experienced between the middle of March and the middle of September; the heaviest precipitation falls between the middle of September and the beginning of March.

The disease occurs principally in the area known as the Fraser Valley district, British Columbia, consisting of the uplands bordering on the north and south sides of the Fraser River, encompassed on the west by Vancouver and by Hatzic on the east in respect to the north side of the river and on the south side as far east as Rosedale and south to the United States boundary, but not including the delta lands. It is recorded as occurring in the following municipalities: Surrey, Langley, Matsqui, Chilliwack, Maple Ridge and the Lillooet district, which are all in the above mentioned area and within a distance of approximately seventy miles inland from the Pacific coast of British Columbia. The disease has also been reported as occurring on Bowen, Galiano, Salt Springs and Vancouver Islands, which are all adjacent to the mainland of British Columbia.

Affected sections of the Fraser Valley may be described geologically as composed principally of glacial drift, overlain in places by small thicknesses of marine deposits which were laid down during glacial retreats of the pleistocene time. "The glacial drift soils occur on the uplands which were formerly, and still are, in large part, heavily timbered. They are mostly sandy or sandy loam soils. The upland areas are being gradually brought under cultivation in places where the valuable part of the forest has been removed in lumber operations." (Johnson (38)). The topography of the land is usually of a rolling nature with occasional fairly level areas. The type of soil may be classed, generally, as coarse, sandy loam, varying from a light brown to a dark chocolate colour. It is usually acid in reaction. The texture is often open and readily leached and drained naturally.

The native tree and herbage growth consists principally of alder (*Alnus glutinosa*, medic.), second growth fir (*Abies balsamea*, L. Mill.), birch (*Betula occidentalis*, Hook), vine maple (*Acer circinatum*, Pursh.), cedar (*Thuja occidentalis*, L.), bracken (*Pteris aquilina*), willow (*Salix* species), hazel

(*Corylus americana*, Walt.), broadleaf maple (*Acer glabrum*, T. & C.), hemlock (*Tsuga canadensis*, L. (Car.), and cottonwood (*Populus deltoides*, Marsh.).

The prevailing cultivated pasture herbage consists of timothy (*Phleum pratense*), June grass or Canada bluegrass (*Poa compressa*), white clover (*Trifolium repens*), red clover (*Trifolium hybridum*), Orchard grass (*Dactylis glomerata*), perennial rye grass (*Lolium perenous*), red top (*Agrostis alba*), meadow fescue (*Festuca elatior*), Yorkshire fog or Velvet Grass (*Holcus lanatus*).

The plant communities dominant in the affected areas are fire or burn indicators such as would be expected to occur on logged and burnt off lands, whereas the plant indicators among the pasture plants are those usually associated with over-grazing (Clements (15)). It is also to be noted that the majority of herbage plants are acid-loving individuals.

The water supply on the majority of red water farms in the Fraser Valley is obtained from seepage wells varying from 12 feet to about 30 feet in depth, with some small creeks, surface water supplies, and a few deep artesian wells (Grauer (24), Mackenzie (48)).

In an endeavour to discover the extent to which local conditions and factors might influence the incidence of the disease, an examination of the quality and chemical composition of the soils, feeding stuffs, and other materials was made. Generally the factors affecting the mineral content of hays and pastures have been classified by Orr (52, 53), and Richardson *et al* (55) under the following headings: (1) Species of plants, (2) Stage of growth of plants, (3) Climatic conditions, and (4) Nature of soil. It has been definitely established that there is an inherent difference in the mineral or inorganic compositions of different species of plants. The legume plants usually contain a large excess of calcium over phosphorus, whereas there is generally an excess of phosphorus over calcium found in the gramineous plants. It is a well known fact that certain progressive changes in composition of plants are incident to advancement in maturity. Although ripening may alter the relationships of the digestible nutrients, it has been found that the percentage of ash often remains about constant. Plants consumed as hay may be lower in their ash content than those consumed as pasture (Hopper and Nesbitt (33)).

With variable climatic conditions, seasonal or otherwise, there is a change in the amount of salts in the soil solutions which is reflected by a variation in the composition of a given species of plant. These variations depend principally upon: (a) the amount of sunshine, (b) the temperature, and (c) the rainfall. The amount of sunshine during the growing season of the plant has a marked influence on the ash content of hays and pastures. During periods of drought the mineral content of plants decreases, particularly in reference to the calcium and phosphorus salts, as ash content of plants varies with the soil moisture. The amount of rainfall is the most important of all factors that influence the chemical composition of grass (Archibald (3), Holtz (32)).

Work done by Lawes and Gilbert (1856-1900) (43, 52), showed that "the mineral composition of the mixed herbage is very directly dependent on the supplies available within the soil. Indeed the composition of the

TABLE 1.—*Mineral composition of soils*
RED WATER FARMS

Lab. No.	Soil Type	Location	Total insoluble matter	Ignition loss	N	SiO ₂	CaO	MgO	P ₂ O ₅	Fe ₂ O ₃	Al ₂ O ₃
1B	Brown Sandy Loam	Aldergrove	79.11	11.79	0.20	....	1.01	1.39	0.34	4.74	5.45
3B	Brown Sandy Loam	Mt. Lehman	77.89	11.29	0.18	....	0.98	1.21	0.29	4.65	6.19
4B	Sandy Loam	Abbotsford	72.63	16.85	0.21	....	0.79	0.98	0.24	5.19	8.65
6B	Sandy Loam	Abbotsford	72.91	16.44	0.35	....	0.84	1.10	0.14	3.65	8.62
2S	Light Sandy Loam	Coglan	78.16	12.15	0.21	0.34	0.75	0.73	0.06	4.86	5.86
3S	Sandy Loam	Pt. Haney	74.69	11.36	0.16	0.38	1.13	1.60	0.13	5.55	7.25
4S	Sandy Loam	Whonnock	72.01	17.68	0.24	0.28	0.87	0.36	0.08	4.49	7.52
6S	Light Brown Sandy Loam	Sardis	79.43	8.12	0.16	0.31	0.99	0.53	0.27	4.85	5.86
7S	Light Sandy Loam	Sardis	80.32	6.47	0.11	0.30	1.69	0.51	0.12	4.84	4.77
5S	Chocolate Loam	Abbotsford	75.73	13.97	0.21	0.42	0.68	0.40	0.40	4.23	7.24
8S	Chocolate Loam	Ft. Langley	74.67	15.08	0.24	0.38	0.60	1.81	0.42	5.21	6.23
9S	Clay Loam	Mt. Lehman	73.16	16.09	0.35	0.82	0.81	1.09	0.09	5.05	7.11
10S	Red Clay Loam	Abbotsford	74.64	14.60	0.28	0.82	0.78	0.54	0.13	4.96	7.17

TABLE 1.—Continued.

Lab. No.	Soil Type	Location	Total insoluble matter	Ignition loss	N	SiO ₂	CaO	MgO	P ₂ O ₅	Fe ₂ O ₃	Al ₂ O ₃
11S	Clay Loam	Glen Valley	78.07	12.18	0.30	0.52	1.00	1.02	0.09	3.35	6.07
12S	Silty Loam	Milner	72.86	12.19	0.20	0.82	0.89	1.62	0.07	4.76	10.19
2B	Light Grey Clayey	Rosebank Is. Chilliwack	75.18	12.60	0.30	....	1.31	1.16	0.45	4.92	6.46
		Average	75.83	13.05	0.23	0.49	0.94	1.00	0.21	4.58	6.91
		Range	72.01–80.32	6.47–17.68	0.11–0.35	0.28–0.82	0.60–1.69	0.36–1.81	0.06–0.45	3.35–5.55	5.45–10.19

NON-RED WATER FARMS											
13S	Clay Loam	Haney	62.05	25.57	0.70	0.21	0.89	1.42	0.39	5.31	8.25
14S ₁	Gray Silty Loam	Essondale	71.66	14.69	0.32	0.65	0.95	1.99	0.12	5.18	8.06
16S	Brown Sandy Loam	Coquitlam	75.15	17.15	0.36	0.29	0.72	0.49	0.13	3.21	6.20
14S ₂	Peaty	Essondale	52.46	42.54	1.20	0.37	1.13	0.94	0.22	2.63	6.38
15S	Peaty	Steveston	70.57	19.95	0.67	0.55	1.01	1.45	0.20	3.60	5.95
		Average	66.38	23.98	0.65	0.41	0.94	1.26	0.21	3.98	6.97
		Range	52.46–75.15	14.69–42.54	0.32–1.20	0.21–0.65	0.72–1.13	0.49–1.99	0.12–0.39	2.63–5.31	6.20–8.25

mixed produce was found to be a somewhat close reflection of the supply available within the range of the roots."

ORR (52) concludes that "the chemical composition of pasture and the value of that composition to the needs of the grazing animal, give a new method of estimating the nutritive value of the pastures; correlations of certain definite nutritional disorders with definite deficiencies; correlations of the excellence of pasture with the proper balance of the nutrients whose amounts can be accurately determined by a chemical analysis." And it is "now recognized that animals are more likely to suffer from lack of inorganic salts, or of organic substances of unknown composition which are required in comparatively small amounts, than from an insufficiency of protein and fat-forming substances and that the deficiencies of mineral elements limit the rate of growth and production, and also they affect the health of the animal."

EXPERIMENTAL DATA

During the Fall months of 1931 a survey was made of a number of typical Red Water farms in conjunction with the economic survey made by MacKenzie (54). During these visits, samples of soils, grass and oat hays, and water were collected. Through the courtesy and assistance of Dr. J. G. Jervis some samples of fresh Red Water urines were obtained, and also one specimen of an infected bladder. The samples of soils, hays, and waters were all composite samples and representative of the material available on the respective farms upon which they were obtained. Some soils were also obtained through the co-operation of Dr. E. A. Bruce of Agassiz, B.C. The methods of analysis used for the soils and feeds were essentially those adopted by the Association of Official Agricultural Chemists (4); methods employed for the waters were those approved by the American Public Health Association (1); the urines were examined principally by methods outlined by Hawk and Bergeim (28). The soils, consisting of 21 samples, 16 of which were obtained from Red Water farms and 5 from disease-free farms in the Fraser Valley, were thoroughly air dried and the material then passed through a 20-mesh per inch sieve used for analysis. The determinations were made on the acid soluble portion, using hydrochloric acid (S.G. 1.115) as the solvent. All figures given in Table 1 are on the moisture free basis and stated as percentage by weight.

From the data in Table 1 for Red Water farm soils it will be noted that the total insoluble matter, representing chiefly the insoluble silicates and certain forms of organic matter, is comparatively high; the soluble silica, in the form of soluble silicates is slightly higher in some instances than might be normally expected; the ignition loss, composed principally of organic matter, carbonates, free and interstitial water, and other volatile constituents is low. Those conditions are to be expected in view of the character of the soils, which all tend to be of a sandy nature containing only small amounts of humus.

The lime content of the soils is not abnormally low, and its relation to the magnesium content is within a safe range. An excess of magnesium is considered toxic to higher plants, particularly when the Ca-Mg ratio is greater than three (Loew (45)). The phosphates are deficient when com-

TABLE 2.—*Ratios to calcium (CaO) in soils.*

RED WATER FARMS

Lab. No.	MgO CaO	P ₂ O ₅ CaO	Fe ₂ O ₃ CaO	Al ₂ O ₃ CaO	Fe ₂ O ₃ +Al ₂ O ₃ CaO	pH
1B	1.38	0.33	4.71	5.42	10.13	5.50
2B	0.89	0.27	3.76	4.94	8.70	5.54
3B	1.24	0.30	4.75	6.06	11.08	5.53
4B	1.23	0.30	6.60	11.00	17.61	4.53
6B	1.30	0.17	5.68	13.41	19.09	4.66
2S	0.97	0.08	6.50	7.83	14.33	5.58
3S	1.41	0.12	4.90	6.40	11.29	4.12
4S	0.42	0.09	5.18	8.67	13.85	4.80
5S	0.59	0.59	6.27	10.72	16.97	4.62
6S	0.53	0.27	4.87	5.88	10.75	5.13
7S	0.30	0.07	2.86	2.82	5.67	4.09
8S	3.04	0.70	8.75	9.99	19.21	3.83
9S	1.34	0.11	6.23	8.78	15.01	4.07
10S	0.69	0.17	6.36	9.19	15.55	4.67
11S	1.02	0.09	3.35	6.07	9.42	3.99
12S	1.82	0.08	5.35	11.45	16.81	4.00
Average	1.13	0.23	5.38	8.16	13.46	4.67
Range	0.30- 3.04	0.07- 0.70	2.86- 8.75	2.82- 13.41	5.67- 19.21	3.83- 5.58

NON-RED WATER FARMS

13S	1.59	0.44	5.97	9.27	15.22	3.66
14S ₁	2.09	0.13	5.45	8.48	13.94	4.33
14S ₂	0.83	0.19	2.33	5.64	7.97	4.08
15S	1.44	0.19	3.56	5.89	9.46	5.04
16S	0.67	0.18	4.46	8.61	13.07	5.28
Average	1.32	0.23	4.35	7.58	11.93	4.48
Range	0.67- 2.09	0.13- 0.44	2.33- 5.97	5.64- 9.27	7.97- 15.22	3.66- 5.28

TABLE 3.—*Mineral composition of feeding stuffs.*

RED WATER FARMS

Lab. No. Soil	Lab. No. Hays Oats	Total ash	CaO	MgO	P ₂ O ₅	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Mn ₃ O ₄	SO ₃
4B	01H	5.88	1.17	0.48	0.41	1.17	0.57	0.11	0.0104	0.13
6B	01O	4.31	0.04	0.24	0.35	1.28	0.12	0.14	0.0076	0.18
2S	02H	5.09	0.66	0.26	0.30	1.91	0.67	0.09	0.0098	0.17
	02O	4.87	0.23	0.21	0.40	1.58	0.42	0.08	0.0029	0.16
3S	03H	5.66	0.60	0.25	0.43	2.39	0.16	0.11	0.0078	0.20
4S	04H ₁	5.53	0.53	0.35	0.40	1.34	0.68	0.08	0.0074	0.17
5S	05H	7.24	1.67	0.55	0.53	1.40	1.76	0.21	0.0050	0.26
6S	06H	7.78	1.27	0.42	0.68	2.08	0.31	0.18	0.0052	0.37
	06O	5.36	0.83	0.33	0.49	1.66	0.16	0.15	0.0055	0.20
7S	07H	8.23	2.03	0.52	0.51	0.76	1.41	0.16	0.0049	0.30
	07O	7.40	0.51	0.35	0.65	2.66	0.83	0.18	0.0068	0.13
9S	09H	5.66	0.98	0.46	0.35	1.51	0.78	0.09	0.0181	0.26
10S	010H	7.21	1.47	0.57	0.51	0.91	0.04	0.06	0.0075	0.23
	010O	6.56	0.41	0.40	0.59	1.23	0.11	0.17	0.0068	0.16
11S	011H	5.51	0.75	0.45	0.40	1.02	0.04	0.06	0.0114	0.25
12S	012H ₁	6.50	0.99	0.59	0.40	0.89	0.04	0.07	0.0083	0.18
12S	012H ₂	6.33	1.01	0.51	0.45	1.08	0.03	0.05	0.0123	0.22
4S	04H ₂	5.10	0.91	0.35	0.34	0.69	0.08	0.06	0.0085	0.18
8S	08H	7.13	1.39	0.54	0.52	0.93	1.54	0.11	0.0084	0.17
	08O	7.86	0.58	0.34	0.63	2.23	0.96	0.28	0.0091	0.19
Average Hays		6.35	1.12	0.46	0.44	1.29	0.58	0.10	0.0096	0.25
Range Hays		5.09–8.23	0.53–2.03	0.25–0.59	0.30–0.68	0.69–2.39	0.03–1.76	0.05–0.21	0.0049–0.0181	0.17–0.37
Average Oats		6.06	0.43	0.31	0.52	1.77	0.43	0.17	0.0064	0.17
Range Oats		4.31–7.86	0.04–0.83	0.21–0.40	0.35–0.65	1.23–2.66	0.11–0.96	0.08–0.28	0.0029–0.0091	0.13–0.20

NON-RED WATER FARMS

13S	013H	5.40	0.74	0.37	0.39	1.44	0.06	0.08	0.0143	0.28
14S ₁	014H ₁	6.68	0.96	0.54	0.50	0.86	0.14	0.07	0.0107	0.45
14S ₂	014H ₂	4.72	0.48	0.43	0.41	0.64	0.08	0.08	0.0294	0.26
15S	015H	7.16	1.33	0.78	0.52	0.92	0.11	0.07	0.0161	0.44
Average Hays		5.99	0.88	0.53	0.45	0.96	0.10	0.07	0.0177	0.36
Range Hays		4.72–7.16	0.48–1.33	0.37–0.78	0.39–0.52	0.64–1.44	0.06–0.14	0.07–0.08	0.0107–0.0294	0.26–0.45
Bracken 01B		6.97	0.37	0.44	0.61	0.69	0.02	0.03	0.0114	0.58

TABLE 4.—*Typical mineral composition of hay plants in per cent on dry basis.*Timothy (*Phleum pratense*)

Location	Ash	CaO	MgO	P ₂ O ₅	Fe ₂ O ₃	SiO ₂	SO ₃	Reference
Ohio		0.19	0.11	0.12				(51)
Massachusetts		0.64	0.33	0.41				(51)
Wyoming		0.37	0.20		0.05			(51)
Wyoming		0.26	0.12		0.04			(51)
Oregon	4.84	0.11	0.06	0.40			0.19	(39)
North Dakota	6.82	0.27	0.26	0.53			0.13	(33)
Minnesota				0.27		3.22		(49)
Minnesota		0.57	0.35	0.31				(21)
Quebec		0.17		0.23				(31)
America and Germany		0.25	0.17	0.31	0.04	1.42	0.37	(29)
Germany		0.79	0.28	0.60	0.01	1.65	0.26	(52)
Average	5.83	0.36	0.21	0.30	0.03	2.14	0.24	

Orchard Grass (*Dactylis glomerata*)

Oregon	5.48	0.11	0.09	0.35			0.12	(39)
Germany		0.31	0.12	0.46	0.03	1.42	0.19	(52)
Average	5.48	0.21	0.10	0.40	0.03	1.42	0.15	

Blue Grass (*Poa pratense*)

Germany		0.33	0.16	0.61	0.02	1.96	0.25	(52)
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Red Clover (*Trifolium pratense*)

Ohio		1.24	0.29	0.18				(51)
Illinois		1.45		0.48				(51)
Oregon	6.64	1.50	0.39	0.40			0.23	(39)
Washington		1.82		0.46				(32)
Quebec		1.51		0.37				(31)
America and Germany		1.60	0.45	0.39	0.07	0.17	0.44	(29)
Germany		2.75	0.94	0.46	0.08	0.32	0.31	(52)
Average	6.64	1.69	0.52	0.39	0.07	0.24	0.33	

Oats (*Avena sativa*, L.)

Ohio		0.11	0.13	0.43				(51)
Oregon	3.68	0.04	0.48	0.89				(39)
Washington		0.18		0.38				(32)
Average	3.68	0.11	0.30	0.57				

pared with the minimum of 0.4% for acid soils, found by Truog (61) to be required for this element in crop production. Harris (27) quotes the results of several workers to show that the phosphorus content of acid soils is generally low and largely unavailable for use by plants. The explanation is offered that acid soils convert any calcium phosphate that may be present into soluble compounds which are either washed out or are fixed in an insoluble form by the formation of iron and aluminum phosphates. This deficiency is evidently one of the limiting factors for the assimilation of the other minerals by the plants grown on these soils. It is most probable that the addition of the proper phosphatic fertilizers to these soils would not only increase the percentage of phosphorus but also of the calcium content in the plants grown on them.

The hydrogen ion concentration values (Table 2) indicate that all these Red Water soils are acidic and the ratios between the calcium, iron, and aluminum would suggest that the cause of the acidity of these soils is probably due to the existence of iron and aluminum compounds which are held absorbed by the soil colloids (Spurway (58)) and associated with the silicates.

The soil conditions found on these Red Water farms are undoubtedly the result of the influence of two important climatic factors, namely, rainfall and temperature. The leaching of calcium has caused an acid reaction of the soil resulting in the probable formation of insoluble salts of phosphorus with manganese and iron. According to Teakle (59) a soil with a pH below 6.0 will hold its phosphorus in combination with manganese. Holtz (32) in his work on the soil series of Western Washington, which are similar soils to those found in the Fraser Valley area, makes a significant statement in respect to the feeds grown on these soils, that in some instances "cows remained normal until they were turned out on virgin cut-over-land pasture where within a year's time they developed Red Water."

The samples of feeding stuffs consisted of sixteen mixed hays, two clover hays, and six oat hays. They were collected on some of the farms from which the soil samples were obtained. The majority of mixed hays were composed principally of timothy, with varying quantities of red clover and alsike. As bracken fern has been prominently mentioned and observed associated with Red Water farms, a sample was obtained and examined in a similar manner to the feeding stuffs. This plant was found more or less present in all samples of hays. All samples were collected from various parts of the mows, thoroughly mixed, air dried, and ground to a uniform fineness. The figures given in Table 3 are on the moisture free basis and in percentages by weight. The typical analyses of feeding stuffs quoted in Table 4 are intended to illustrate the variations that might be expected in the species composing the hay mixture grown in the affected areas.

It should be recalled that the grasses predominate in the above hays, the only legume present in appreciable amounts being red clover. Also, the fact should be emphasized that the majority of native browse and cultivated plants found upon the affected farms were of an acid-loving nature. However, this condition is to be expected as the non-legumes are less sensitive than legumes to soil reactions and are not likely to fail in any community because of acid-reacting soils (39).

It is to be noted that the soluble silica, aluminium and iron are comparatively higher in the feeds grown on the Red Water farms, and their range wider than those grown on the non-Red Water farms. It is possible that these two constituents may be significant factors in this disease.

The calcium content of the feeding stuffs grown on Red Water farms is comparatively higher with a wider range than those produced on the disease-free farms, and the manganese content is distinctly lower in the majority of cases. The physiological effect of this slight deficiency may be of importance, as manganese is now considered an essential element of plant growth and functions in the synthesis of chlorophyll (46, 52). It occurs in the ash of oxidizing enzymes (Bertrand (5, 6)), and so probably assists in the process of oxidation in animal nutrition.

The samples of waters were composite ones taken from all sources of supply used by the animals on the respective farms. The figures are stated in parts per million in Table 5. The analyses of the water supplies of these farms indicate that none of them is of a highly mineralized character, nor do they contain any element in quantities that might be considered detrimental to the cattle using them.

The samples of urine were obtained by catheterizing the animals, and preserved by the addition of a small quantity of toluene. The specific gravity of these samples varies within a wide range, but the figures are comparable to those obtained by Bull, Dickinson and Dann (9); their data are summarized as follows:

Normal Cattle: Mean 1.033 (range 1.015 to 1.047)

Red Water Cattle: Mean 1.028 (range 1.014 to 1.043)

TABLE 5.—*Mineral content of waters.*

RED WATER FARMS.

Lab. No. Soil	Lab. No. Water	Source	Total solids	CaO	MgO	SiO ₂	Cl	SO ₃
4B and 6B	001W	Surface and well	44.0	7.1	3.5	4.6	3.5	0.3
2S	002W	Well near barn	200.0	30.3	29.6	13.4	16.6	5.8
3S	003W	Running stream	77.0	5.7	4.6	9.2	3.4	3.4
4S	004W	Well	45.0	5.7	2.6	5.8	4.2	1.1
5S	005W	Well	74.0	14.3	4.3	12.4	5.1	1.0
6S	006W	Well	72.0	11.4	4.5	12.4	2.6	0.1
7S	007W	Well	72.0	21.1	3.4	7.0	2.9	1.0
10S	0010W	Piped spring	46.0	5.3	1.1	4.2	3.6	0.3
Average			78.7	12.6	6.7	8.6	5.2	1.6

NON-RED WATER FARM

13S	0013W	Piped hillside spring	66.0	7.4	3.9	9.8	2.4	1.4
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The silica content may be significant when considered in conjunction with the silica content of the herbage produced on Red Water farms. Forbes *et al*

TABLE 6.—*Urines. Red Water animals.*
(Grams per litre.)

Laboratory Number	Specific Gravity	Silica (SiO ₂)	pH
1 U	1.0093	0.128	8.03
2 U	1.0160	0.088	7.99
3 U	1.0288	0.078	7.75
4 U	1.0348	0.269	7.94
5 U	1.0164	0.277	8.33
Average	1.0210	0.168	8.01
Range	1.0093–1.0348	0.078–0.277	7.75–8.33

urines was usually between 7.7 and 8.1; the data recorded by Shutt and Robinson (57) give the following ranges:

Red Water Cattle from 7.15 to 8.40.

Normal Cattle from 7.15 to 8.64.

The figures recorded in Table 6 may thus be considered normal in respect to this reaction.

TABLE 7.—*Mineral content of bladder.*

Laboratory number	1J	
Total ash	1.652	
	<i>Original</i>	<i>Ash</i>
Total Silica (SiO ₂)	0.057	3.43
Calcium (CaO)	0.142	8.57
Magnesium (MgO)	0.257	15.53
Phosphates (P ₂ O ₅)	0.687	41.58
Sulphates (SO ₃)	0.223	13.48

definite conclusions can be made until compared with disease free material.

In an investigation of the lesions resulting from ingestion of silica, Policard (54) concludes that particles of silica dioxide (SiO₂) are attacked by

TABLE 8.—*Coral rock flour.*

Laboratory Number	1C
Moisture	0.26
Loss on Ignition	44.63
Silica (SiO ₂)	0.34
Mixed Oxides (R ₂ O ₃)	0.56
Sulphates (SO ₃)	0.30
Calcium Oxide (CaO)	50.66
Magnesium Oxide (MgO)	3.55
Nitrogen (NH ₃)	0.045

animals.” In view of the fact that there is an analogy existing between the

(22a, 23) in their work on the mineral metabolism of the milch cow, have demonstrated the existence of an extensive metabolism of silica. The retention of this element from rations containing large quantities of timothy hay is surprisingly large, silica being found in considerable quantities in the urine, but not in weighable amounts in milk.

The hydrogen ion concentrations of these urines show them all to be with an alkaline reaction. Bull *et al* (9) report that the pH of Red Water urines was usually between 7.6 and 8.1 and the pH of the normal

A bladder was obtained from a cow which had been affected with the disease for some time. A portion showing characteristic lesions was dried to constant weight and ashed. The figures given are on the moisture free basis and are stated as percentage by weight in Table 7. The data are interesting because the silica content may be significant, but no

definite conclusions can be made until compared with disease free material. In an investigation of the lesions resulting from ingestion of silica, Policard (54) concludes that particles of silica dioxide (SiO₂) are attacked by the cellular juices and the resulting fibrosis with its degenerated cytoplasm is rich in silica. Mills (50) also dealing with the action of siliceous materials on animal tissues states that “Siliceous spicules, when introduced into the tissues of animals, are slowly but definitely dissolved, proving conclusively that silica is soluble in the tissue fluids of

carbon and silicon compounds and that silicon may replace other elements in the formation of organic compounds, the recent (1932) work of Johlin (37) in isolating a substance, by electrodialysis of animal tissues, containing silicic acid and carbohydrates is interesting and may have important biological significance.

Samples of coral rock flour were examined; these were taken from four different lots of this material at the University of British Columbia.

The figures given in Table 8 as percentage by weight are the average for all samples. The coral rock flour is probably of marine origin. It was examined for the presence of calcium carbonate in the form of aragonite by the tests discovered by W. Meigen as reported by Clarke (12), who states that "in studying the formation of shell limestone or coral

TABLE 9.—*Comparative composition of coral rock flour and coral.*

	Coral Flour	Red Coral Tressler (60)	Black Coral
Calcium carbonate (CaCO_3)	90.04	86.974	85.801
Magnesium carbonate (MgCO_3)	7.01	6.804	6.770
Calcium sulphate (CaSO_4)	0.51	1.271	1.400
Ferrous oxide (FeO})	....	1.720	0.800
Mixed oxides (R_2O_3)	0.56	....	....
Phosphoric acid (P_2O_5)	....	....	....
Silica (SiO_2) etc.	....	1.331	1.559
Silica (SiO_2)	0.34	....	....
Moisture	0.26	0.550	0.600
Organic matter	1.32	1.35	3.07
	100.04	100.00	100.00

rock, it is desirable to take account of the fact that calcium carbonate exists in at least two geologically important modifications—calcite and aragonite." It is probable that the calcium carbonate contained in this material is valuable as a source of calcium in the coral rock flour-soda bicarbonate treatment, reported upon by Grauer (24) and MacKenzie (48).

GENERAL DISCUSSION

The data obtained may be considered as fairly representative of the composition of the materials examined. Although the results may be interpreted as only suggestive of a probable explanation, they may upon further investigation lead to the causative factor of this disease.

The soils studied may be rated as being of a poor quality and need to be improved by a proper system of cultivation and fertilization; the composition of the feeding stuffs is a reflection on the soil conditions. It is possible that the silica content of the feeds may be abnormal, and, together with the high aluminium content, may be an important factor in the causation of this disease. The manganese content may be considered as a possible factor, especially as it may function in the synthesis of chlorophyll and be present in an inorganic form, which during the process of metabolism within the animal may cause abnormal conditions.

It seems important that the inorganic composition of a large number of samples of urines, and bladders should be examined; also the examination of the flesh and milk of diseased animals might be included, because it is believed that such information would throw considerable light upon this problem.

SUMMARY

1. A detailed analysis of soils, feeding stuffs, waters and other materials from Red Water and non-Red Water farms has been compiled and comparisons made between them.
2. Red Water occurs on farms where the soils are comparatively low in fertility.
3. The soils are of an acid nature, readily leached, with a tendency to be low in phosphate, nitrogen, and organic matter.
4. The hays and other roughages are generally low in available mineral elements.
5. The herbage is significantly high in silica and aluminium, and possibly low in manganese.
6. The probable causation of the disease is of nutritional origin, either from ingested irritant material or from material elaborated in the animal's system during metabolism.
7. Further investigational work should be conducted on the composition of the urines, bladders, flesh and milk of diseased animals.

ACKNOWLEDGEMENTS

For making these studies possible by kindly consenting to the use of the facilities of the Food and Drugs Laboratories of the Department of National Health in Vancouver, B.C., the obligation to Dr. J. A. Amyot, Deputy Minister, and to Mr. H. M. Lancaster, Chief Dominion Analyst of the Department of National Health, Ottawa, Ontario, is gratefully acknowledged. Thanks are expressed to Dean F. M. Clement and other members of the Faculty of Agriculture of the University of British Columbia, for their helpful advice and interest in this problem; to Dr. J. G. Jervis, Dr. E. A. Bruce and Mr. J. C. MacKenzie, for their services in the collection of materials for analysis; to Mr. H. O. Tomlinson, for his valuable suggestions and technical assistance; and to the various farmers visited for their important aid in generously supplying materials and information; and to the Imperial Bureau of Animal Health, Weybridge, Surrey, England, and the numerous correspondents for their interest in replying to enquiries concerning various phases of the problem.

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A REPORT OF SOME INVESTIGATIONS INTO THE CAUSE OF SWEET CLOVER (*MELILOTUS*) DISEASE

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[Received for publication November 15, 1932]

INTRODUCTION

That which has been appropriately designated "Sweet Clover Disease" was first reported as a clinically recognizable disease in 1922. Experimental studies were first undertaken by Schofield (1) in the same year and led to the conclusions, "That the disease is produced by a toxic substance which is present in mouldy sweet clover. There is much evidence that certain moulds are responsible for the formation of this poisonous principle. That there is no evidence to show that the feeding of good sweet clover hay or ensilage can produce the disease in question." The term "good" here is taken to denote relatively non-moulded sweet clover. These findings appear to have been generally accepted by technical agriculturists and to-day most well-informed stockmen believe that it is unsafe to feed mould-damaged sweet clover to stock and further that only visibly moulded sweet clover can induce the disease. Since 1922, however, numerous instances have come to the attention of the senior author of heavily-moulded sweet clover fed for periods of ninety days and over having failed to induce disease, and conversely of cattle on a relatively mould-free (determined by mycological study) diet of sweet clover having succumbed, exhibiting typical lesions of the disease. Thus the causal relation of moulds to the disease has seemed to us not clearly established.

What at the time appeared as a ray of enlightenment on the problem was the publication of Cannon and Greenwood (2). These investigators working with rabbits and using especially well cured sweet clover hay succeeded in developing the typical blood condition associated with sweet clover disease, namely definitely delayed clotting time. Associated with this was a marked reduction of the serum calcium and the data being insufficient to warrant definite conclusions being drawn, the authors suggest, "The decline in serum calcium brought about by sweet clover is probably linked with the failure of the blood to clot in 'poisoning'".

Meantime sweet clover disease continues to take its toll in death of cattle. Lewis (3) reports for the years 1930, 1931 and 1932, a total of 83 cattle deaths in Manitoba investigated by him all exhibiting typical lesions of the disease. The number of deaths unreported and uninvestigated cannot of course be computed, but it is reasonable to suppose this is considerable especially in view of the fact that the disease is still being wrongly diagnosed as blackleg which in some respects it simulates.

It is apparent, therefore, that this is a problem of major economic importance, not only because of the cattle mortality associated with it, but also because of the obvious agronomic difficulty involved. The scientific aspects are equally important and in the present status of the problem are especially intriguing to the biochemist. The pathology of the disease is not discussed

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in this paper having been fully described by Schofield (1) and by Roderick and Schalk (4).

EXPERIMENTAL

The experimental work herein reported may conveniently be divided into three separate phases or experiments designed chiefly to determine the soundness of old and new theories concerning the fundamental cause of sweet clover disease. Ten stocker heifers each of approximately 500 pounds weight and of mixed Angus, Shorthorn and Hereford breeding together with rabbits constituted the experimental subjects.

Experiment No. 1. The object of the first experiment was to determine whether feeding sweet clover for long periods to the bovine introduces a serum-calcium interference and associated delayed blood clotting time as was found by Cannon and Greenwood (2) in the case of rabbits.

An experimental group of six heifers was maintained on a diet of sweet clover hay (fed *ad lib.*), 2 pounds per head daily of ground barley, and distilled water. A check group of four heifers was maintained on a diet of alfalfa, 2 pounds per head daily of ground barley, and distilled water. Animals were confined in individual stalls and not at any time exposed to direct sunshine. Sweet clover hay used in this experiment was bright and apparently well cured. The mycologist's report on this indicated very little fungi present, such as there was including: "Cladosporium Sp., a common mould everywhere. Yeast cells. Pycnidia of Microdiplodia. Ascochyta, probably *A. meliloti*. Rust spores from cereals. Two species at least of *Penicillium*, ubiquitous moulds. Two species of *Mucor*. Some bacteria." Experimental and check groups were maintained on the respective diets for 188 days during which the animals remained in health. Blood was taken for the determination of calcium, phosphorus and clotting time at approximately 21-day intervals.

The blood analysis is presented in Tables 1 and 2. Not at any time during the experiment was delayed blood clotting time in evidence, therefore such is omitted from the tables. The variations in both calcium and phosphorus are not significant being according to Palmer *et al* (5,6) well within the range of normal variation.

Experiment No. 2. An outbreak of sweet clover disease terminating in death of 14 cattle, having occurred on a Manitoba farm in the winter of 1931, a sheaf of the toxic clover was obtained. This material exhibited a dark

TABLE 1.—Calcium determinations in terms of milligrams per 100 c.c. blood serum.

Date	Experimental group. Sweet clover						Check group. Alfalfa			
	No. 5	No. 16	No. 7	No. 18	No. 9	No. 10	No. 1	No. 2	No. 13	No. 4
May 7	10.8	10.4	9.8	10.0	10.5	12.1	9.8	12.1	11.7	11.9
" 12	10.2	9.8	8.3	10.7	10.0	10.3	9.4	9.5	10.3	10.3
June 3	10.6	10.8	10.6	10.2	11.1	10.7	10.6	10.6	10.8	10.9
" 24	11.1	10.0	10.2	11.3	10.0	10.8	10.4	10.2	10.2	9.8
July 18	11.3	11.7	11.1	10.6	11.2	11.3	11.3	11.0	10.6	10.5
Aug. 11	10.2	12.0	10.6	10.3	12.9	11.1	10.9	10.6	9.3	11.0
" 31	10.4	10.4	9.8	10.8	10.3	9.9	8.7	9.0	10.7	9.1
Oct. 6	11.8	11.7	11.1	11.5	11.1	11.3	—	9.4	11.6	11.2
Nov. 16	11.2	10.5	12.0	11.6	10.9	10.9	9.8	10.7	10.5	10.6

TABLE 2.—*Phosphorus determinations in terms of milligrams per 100 c.c. blood serum.*

Date	Experimental group. Sweet clover						Check group. Alfalfa			
	No. 5	No. 16	No. 7	No. 18	No. 9	No. 10	No. 1	No. 2	No. 13	No. 4
May 7	6.2	6.3	6.9	6.3	7.4	5.6	5.7	5.7	7.5	5.6
" 12	8.2	6.6	3.3	7.8	6.8	6.6	8.7	8.6	7.3	6.5
June 3	6.7	5.6	6.7	7.1	7.3	7.7	6.5	6.3	7.7	6.3
" 24	6.2	5.0	6.4	6.5	5.9	6.5	6.4	6.5	6.3	6.7
July 18	5.3	5.1	6.2	6.8	5.0	6.7	6.2	4.8	6.4	6.7
Aug. 11	6.4	5.8	6.6	6.8	6.1	6.9	6.7	5.6	6.5	6.6
" 31	6.0	6.8	5.8	7.8	6.2	5.8	5.9	6.7	6.2	6.8
Oct. 6	5.7	6.5	—	5.8	6.3	5.9	—	5.9	6.5	5.7
Nov. 16	5.3	5.0	6.4	7.1	6.9	5.8	6.5	6.3	6.0	7.1

brown coloration and was visibly heavily moulded. Mycological study revealed the presence of "a predominant whitish mould—*Penicillium brevicaulis*". It seemed probable if mould action were responsible for the toxicity that this would be the one involved. This mould was cultured on neutral lactose-ager, propagated on ground oat hulls, and from an extensive growth obtained a large water suspension was prepared. A successful attempt was made to inoculate a stack of sweet clover hay with this particular mould by sprinkling each layer during the building process with the water suspension. The resulting hay was heavily moulded, the *Penicillium brevicaulis* greatly predominating.

The general conditions of Experiment No. 1 were repeated in Experiment No. 2, the changed factor being the sweet clover hay which in Experiment No. 2 was that which had been artificially mould-inoculated.

Despite the mouldy and apparently unpalatable nature of the sweet clover fed in this experiment, difficulty in inducing consumption of a full

TABLE 3.—*Calcium determination in terms of milligrams per 100 c.c. blood serum.*

Date	Experimental group. Sweet clover (mouldy)						Check group. Alfalfa			
	No. 5	No. 16	No. 7	No. 18	No. 9	No. 10	No. 1	No. 2	No. 13	No. 4
Nov. 16	11.2	10.5	12.0	11.6	10.9	10.9	9.8	10.7	10.5	10.6
" 21	10.6	10.4	11.6	11.4	12.2	10.3	—	—	—	—
" 28	11.5	10.8	12.7	11.4	11.6	12.2	—	—	—	—
Dec. 5	11.6	10.9	11.4	11.0	11.5	11.9	—	—	—	—
" 22	10.9	10.4	10.8	10.5	10.5	11.5	10.6	10.8	10.3	11.6
Jan. 22	10.1	9.6	9.7	10.0	9.5	10.2	9.7	10.5	10.3	10.4

TABLE 4.—*Phosphorus determinations in terms of milligrams per 100 c.c. blood serum.*

Date	Experimental group. Sweet clover (mouldy)						Check group. Alfalfa			
	No. 5	No. 16	No. 7	No. 18	No. 9	No. 10	No. 1	No. 2	No. 13	No. 4
Nov. 16	5.3	5.0	6.4	7.1	6.9	5.8	6.5	6.3	6.0	7.1
" 21	6.4	5.8	6.1	7.2	6.4	6.5	—	—	—	—
" 28	6.9	7.7	6.4	7.8	7.5	7.6	—	—	—	—
Dec. 5	6.0	6.3	7.2	7.9	7.2	6.8	—	—	—	—
" 22	6.5	6.9	7.4	7.6	7.0	6.6	6.5	6.3	5.6	7.2
Jan. 22	5.9	5.3	5.4	5.6	5.8	6.1	6.1	5.4	6.2	5.6

ration was not experienced, the average daily intake per animal being 20 pounds.

The duration of Experiment No. 2 was 77 days. Throughout the period, daily clinical observations on the experimental group did not reveal anything abnormal. Blood clotting time was not delayed at any stage of the experiment and the serum calcium and phosphorus variations (presented in Tables 3 and 4) were not significant.

Experiment No. 3. Having failed to induce disease by feeding relatively mould-free sweet clover hay over an extended period and heavily moulded sweet clover hay over a period within which the disease ordinarily develops, an attempt was next made to induce the disease by feeding hay known to have the disease-producing qualities.

Nine cattle having died, all exhibiting the typical lesions of sweet clover disease, a quantity of hay from the same stack out of which the dead cattle had been fed was obtained. This hay was of a dark brown color and possessed of the sweetish tobacco-like odour which we have come to regard as fairly typical of sweet clover hay having the disease-producing qualities. The mycologist's report on this sample was that of a relatively mould-free hay. Conspicuous by its absence was the species *Penicillium brevicaulis* which fact further exonerates this mould as a causal agent of the disease. The test group in this experiment was reduced to four animals. A rest interval of fourteen days was allowed between Experiments Nos. 2 and 3 during which animals were exercised, exposed to sunshine and given general good treatment.

TABLE 5.—Calcium and phosphorus determinations in terms of milligrams per 100 c.c. blood serum

	Experimental group. Sweet clover				Check group. Alfalfa				
	No. 4	No. 7	No. 9	No. 13	No. 1	No. 2	No. 5	No. 10	No. 18
Calcium.....	10.3	10.6	9.0	10.1	9.5	9.8	9.9	10.6	10.9
Phosphorus.....	—	—	3.6	5.6	5.6	5.9	5.9	5.5	5.6

Whereas in Experiment No. 2 the mouldy hay was consumed readily from the beginning, in Experiment No. 3 twenty-one days had elapsed before animals were consuming a full hay ration of twenty pounds. This may have been due either to the fact that during the rest period animals were receiving high quality alfalfa hay or to an inherent unpalatability of the sweet clover hay.

Clinically recognizable symptoms of impending disease did not appear in this experiment which supports the observations of Roderick and Schalk (4). The onset of the disease is sudden. Animals remained in apparent health until the morning of the forty-second day of the feeding period when extensive haemorrhagic swellings appeared on one animal (No. 4) and smaller ones on another (No. 13). Transfusions of defibrinated blood saved animal No. 13, but failed to prevent death in animal No. 4, doubtless due to the advanced stage of the disease. The blood of No. 4 had completely lost its clotting power while that of Nos. 13, 7 and 9 was greatly delayed. Blood

was drawn four days prior to the appearance of lesions and calcium and phosphorus determinations made which are presented in Table 5.

Experiments with rabbits. Two experiments were conducted with rabbits both of which merely confirm results since published by Roderick and Schalk (4) as follows:—

(1) With rabbits sweet clover disease develops in from eleven to eighteen days.

(2) The toxin contained in disease-producing sweet clover is not water soluble.

Three rabbits confined to a diet of sweet clover hay and distilled water all died, one on the eleventh day and two on the fifteenth. Postmortem examination revealed the thorax and abdomen of each flooded with uncoagulated blood.

The water solubility of the toxin of damaged sweet clover was determined by soaking hay (proven pathogenic for cattle) in distilled water for a period of fourteen days.

Two rabbits were maintained for a period of twenty-five days on a diet of the water extract and crushed oats. The extract was freely consumed yet the rabbits remained in health throughout the experimental period.

SUMMARY

1. Sweet clover disease does not appear to be associated with either calcium or phosphorus interference.

2. The belief generally held that only mould-damaged sweet clover is capable of causing the disease is not substantiated by these experiments. On the contrary disease was induced in our experimental subjects by feeding a sweet clover hay relatively mould-free. Furthermore, feeding of heavily moulded sweet clover artificially inoculated with a mould isolated from sweet clover proven pathogenic failed to induce disease.

3. A dark brown coloration and tobacco-like odour seem to be typical of sweet clover possessed of disease-producing qualities.

ACKNOWLEDGMENTS

The authors gratefully acknowledge their indebtedness to Guy Richard Bisby, Professor of Plant Pathology, Manitoba Agricultural College, for his reports on mycological studies of numerous sweet clover samples.

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THE INFLUENCE OF SOIL MOISTURE DIFFERENCES ON APPLE FRUIT COLOR AND CONDITION OF THE TREE

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[Received for publication December 24, 1932]

INTRODUCTION

This investigation developed as a part of, and during the early years of an apple tree manurial experiment. The project occupies 8.68 acres and includes some 380 trees. It consists of applications of nitrogen, phosphorus, and potassium carrying fertilizers, alone and in combination with each other. The soil is reported by the soil chemist as Plainfield sand, low in organic matter, nitrogen, phosphorus and potash. It is acid in reaction ranging from pH 6.0 to 6.5. While this soil is poor and hungry, it has been found that very reasonable applications of commercial fertilizers alone will produce both good quality and quantity of fruit. The experiment was started in the spring of 1930.

FRUIT COLOR

Color Variations. The first crop harvested in the fall of 1930 clearly indicated that some factor or factors, other than the treatments given, were affecting fruit color. The variation in color was both qualitative and quantitative. The difficulties surrounding quantitative color determinations, coupled with the equal importance of quality of color, resulted in the emphasis being placed on the latter. It proved easily possible to divide the trees into three general color groups, viz.: (1) trees bearing fruit of a deep, clear, bright red; (2) fruit of a dull greyish shade with very little discernable red; (3) intermediate between groups 1 and 2. Fruit from trees in group 3 had a considerable amount of red color although it was duller than group 1. There were, as might be expected, a number of trees which came between the groups designated.

Figure 1 gives the fertilizer treatment, with the color distribution for 1932. Table 1 summarizes the color range by plot and treatment. The same general color range held true for 1930 and 1931 except that in these two years plots 2, 4 and possibly 6 had a little higher color than in 1932, which will be referred to later.

Figure 1 illustrates the somewhat patchy distribution of color grades over the area. However, a distinct improvement is to be seen from row 10 to 20. The last few rows show all high color. The odd numbered trees, from 7 on, were omitted because they consisted of a variety which normally only shows red coloration to a slight degree. Blanks in the other rows chiefly represent non-fruiting trees or those with a very small crop.

Considering fruit color on the basis of fertilizer treatment (Figure 1) and summarized by plots (Table 1) it is at once clear that fertilizers were of very minor, if of any importance, during the period studied.

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TABLE 1.—Color range of fruit on plots receiving various fertilizers*

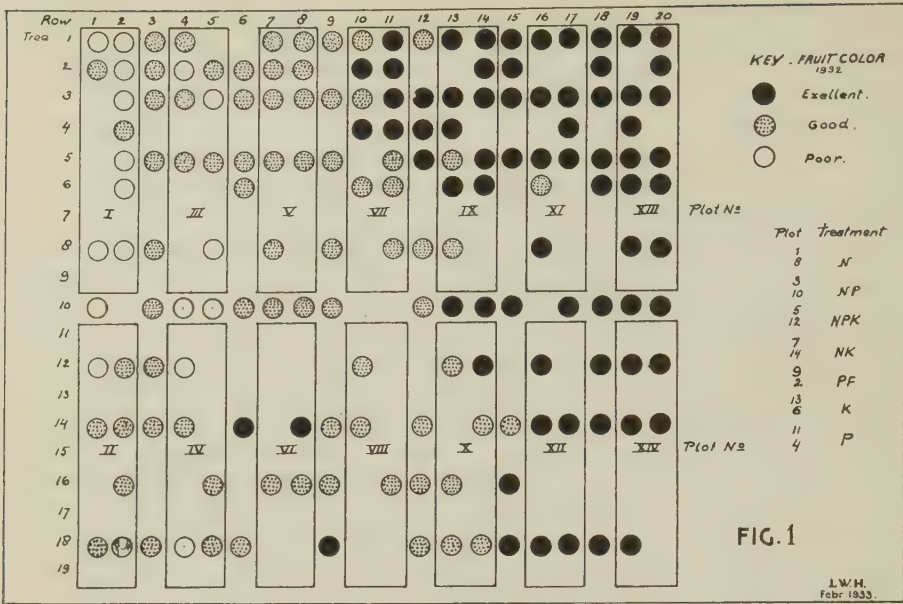
Plot No.	Fertilizer	Fruit color range	Predominant color
1	Nitrogen	0 to —	0
8		—	—
3	Nitrogen & Phosphorus	— to 0	—
10		— to X	—
7	Nitrogen & Potash	— to X	even
14		X	X
5	Nitrogen, Potash & Phosphorus	—	—
12		X	X
9	Phosphorus & Potash	X to —	X
2		— to 0	—
11	Phosphorus	X to —	X
4		— to 0	—
13	Potash	X	X
6		— to X	—

*Key: X Excellent color. — Good color. 0 Poor color.

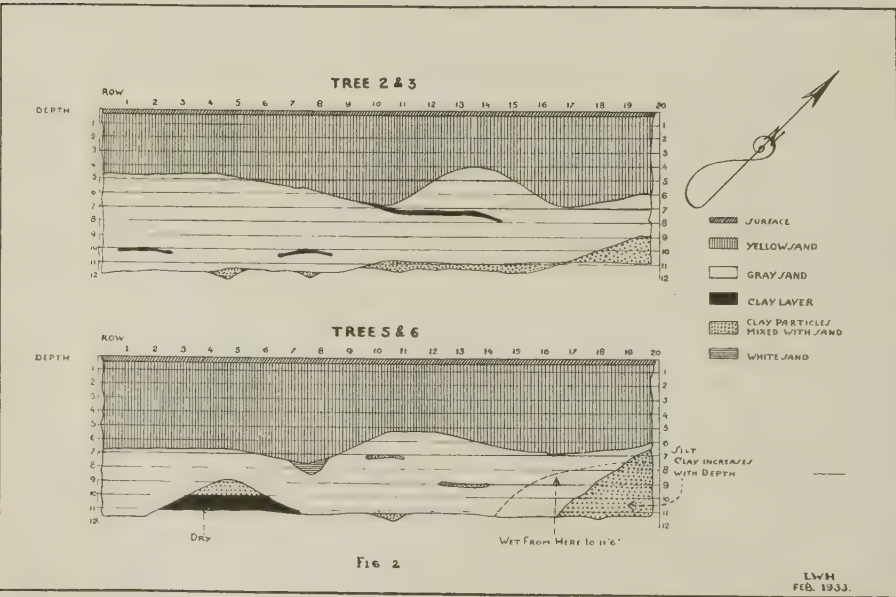
Soil Investigation. An exploration of the soil was made to a depth of 11.5 feet, using a soil auger adapted to the purpose. Borings were made every 90 feet each way across the plots. The resultant profiles are shown in Figures 2, 3 and 4. Since sampling was only carried out every 90 feet each way, the detail between had to be filled in as indicated by the adjacent borings. Tree roots were found at various depths and from this it could be concluded that some roots had penetrated to the depths explored. The soil was not subject to mechanical analysis and consequently the exact composition is unknown. The silt layers contained considerable sand while the clay portion in the mixed clay and sand areas varied from small amounts to a preponderance of clay. These areas are shown alike on the charts for ease in reproduction.

The profiles in Figures 2, 3 and 4 reveal a uniform soil to 6 or 7 feet completely across the area and under rows 1 to 7 to a depth of 9 to 11 feet. From rows 9 to 12, depending on the profile observed, clay areas, or clay and sand areas of varied but considerable extent occur at depths of 7 feet and below, which continue to the end of the plots, i.e. row 20. At row 16, usually, and continuing to the end of the plots, is a water saturated soil from a depth of about 8 feet to 11½ feet. The actual cause of this latter condition has not as yet been ascertained.

Table 2 is a characteristic set of moisture determinations from these profiles. The lower data are from between trees 1 and 2, 30 feet north of the profile at the position of trees 2 and 3 in Figure 2. It is very evident that the trees at row 17 and 18 have a much greater water supply than rows 2 and 3 from 7 feet downward. The upper data concern the profile between trees 11 and 12 (Figure 3) and are carried almost completely across the plots. It would seem that as soon as a clay or clay and sand layer of any considerable size is reached, the percentage moisture increases from a level of 2 - 5% to



Fruit color distribution, per tree, across the plots of an orchard fertilizer experiment. The odd numbered rows from 7 to 19 inclusive consist of a variety which does not develop a decided red color. The remaining blanks are chiefly non-bearing trees or those with a light crop.



SOIL PROFILE. The position of each profile may be located by the tree numbers at the top and by referring to Figure 1. Borings were made between the tree numbers indicated. Clay with sand areas contain varying, unascertained proportions of the two soils.

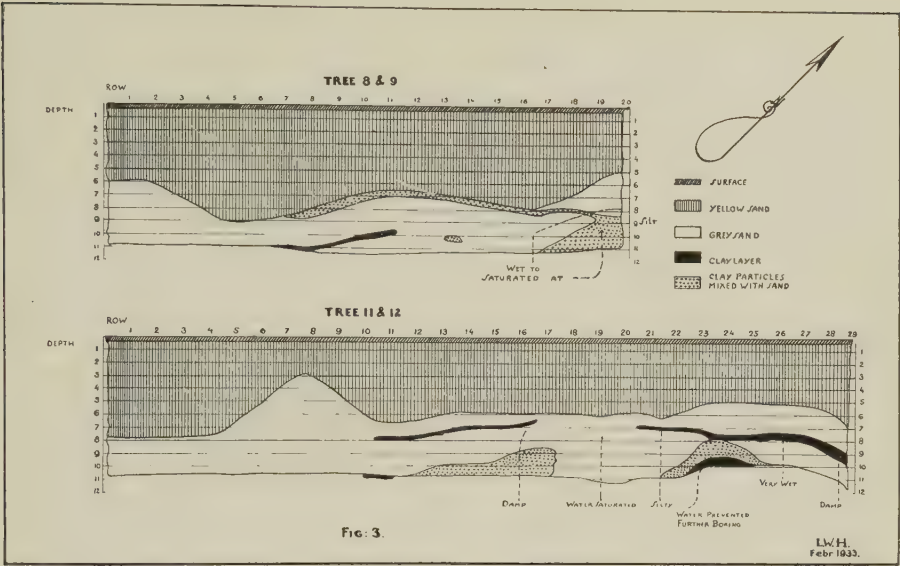


FIG. 3.

L.W.H.
Febr. 1933.

SOIL PROFILE. The position of each profile may be located by the tree numbers at the top and by referring to Figure 1. Borings were made between the tree numbers indicated. Clay with sand areas contain varying, unascertained proportions of the two soils.

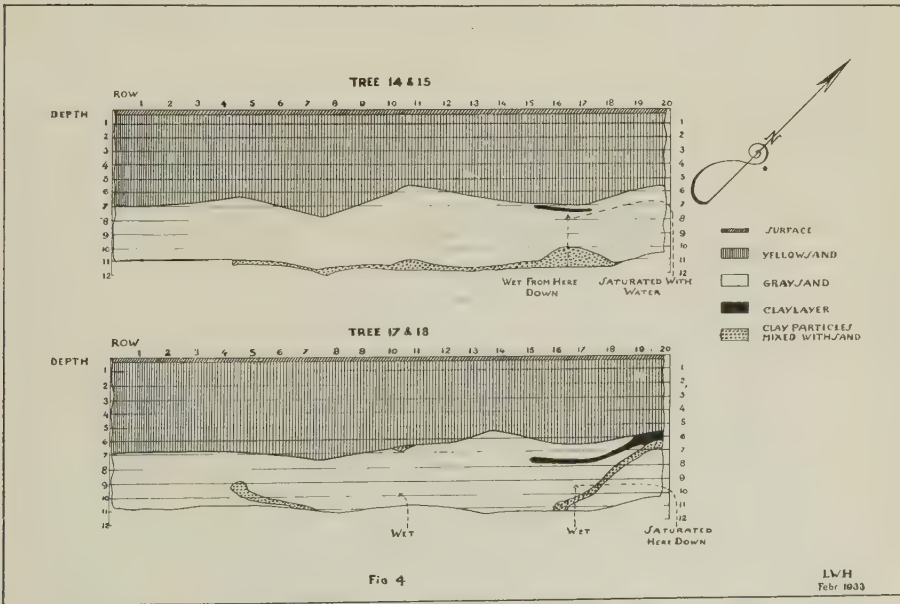


FIG. 4

L.W.H.
Febr. 1933.

SOIL PROFILE. The position of each profile may be located by the tree numbers at the top and by referring to Figure 1. Borings were made between the tree numbers indicated. Clay with sand areas contain varying, unascertained proportions of the two soils.

12 - 20%. The higher moisture continued to where boring was discontinued whether or not the clay layer had given place again to sand. This condition is constant except between trees 5 and 6 (Figure 2) under row 4 to 6 where a body of clay occurs which is low in moisture. Because of the distance between borings it is not warranted to confine the probable effectiveness of these soil conditions to a narrow area. It is clear that the rows with good fruit color have a much greater supply of moisture than those having poor fruit color.

Discussion. There has been no sign of wilting or of Leaf Scorch on the trees in the plots. However, greyish green leaf color (in the late summer) and reduced leaf size pointed clearly to the existence of an inadequate water supply at some time during the season, probably commencing with the advent of hot dry weather in late June or early July. This opinion was substantiated by the soil explorations.

TABLE 2.—*Soil moisture determinations. July, 1932**

Between Trees 11 and 12 Depth in Feet	Percentage of moisture between rows				
	4 and 5	10 and 11	13 and 14	16 and 17	19 and 20
3.	3.0	3.4	2.6	5.4	2.2
6.	3.6	5.8	7.8		
7.5		4.0	13.6		16.0
8.		3.0		17.4	
9.	3.6			17.8	
10.5				17.8	20.6
11.	4.6	14.8	12.8		
Trees 3 and 4	Rows 1 and 2†	17 and 18†			
3.	1.7	3.6			
5.	4.4	3.4			
7.5	2.7	21.5			

*Surface soil and to 2 feet showed in all cases percentage of moisture of from 3-5. Soil oven dried at 90°C. Moisture calculated on basis of original weight.

†Taken on September 12, 1930.

There is no evidence at hand to indicate what may be the effects of the various fertilizers on fruit color in the future. Up to the present there has been no detectable difference in color that could be attributed to any fertilizer treatment, except in so far as a slight reduction can be associated with the use of nitrogen on some plots. Table 1 and Figure 1 both suggest this. It was previously mentioned that plots 2, 4 and 6 did not exhibit as marked reduction in color in 1930 and 1931 as was the case in 1932, although color has never been first class on this area. Due to lack of tree growth an application of nitrogen equivalent to that given the other plots was used on these plots in the spring of 1932, although the experiment called for the use of potash and phosphorus only. There was clear evidence in tree appearance, compared with adjacent untreated trees, that the nitrogen was utilized. That this nitrogen was to some extent responsible for the greater color difference in 1932, compared to 1930 and 1931, can hardly be doubted. It cannot be considered, however, as other than contributing to and accentuating the effect of an existing condition of primary importance. The actual cause, whether it be increased leaf size, transpiration complexes or nutritional

effects, was not investigated. It is noteworthy that plots 2, 4 and 6 had phosphorus and potash applied for three years while the application of nitrogen was only 150 lbs. per acre and for one year. The variety Scarlet Beauty, harvested the 9th of September showed even more clear cut color differences than did Baldwin which was mature a month later, harvested October 14th, 1932. It was impossible to illustrate this condition in chart or table form. The color differences reported are quite distinct in type from those usually associated with delayed maturity resulting from excessive or late applications of nitrogen or other growth increasing practices. Barrs (10), Batchelor (11), and Lewis (12) have reported similar color-moisture relations, under irrigation with pears, apples, and peaches respectively.

SOME TREE RESPONSES RELATED TO SOIL CONDITIONS

Some of the information published on fruit plant response in relation to soil conditions has a bearing on the data and discussion which follow. Heinicke (3) reports the effects of soil, particularly a compact clay layer at 1 foot in depth, on apple tree growth, within relatively short distances. Partridge and Veitch (1) worked to depths of approximately four feet with grapes on a soil closely resembling the one used in the Ontario experiments. They found that the depth of the humus layer was the main soil factor influencing growth and production. The differences were related to a narrow range of 3 inches variation in depth of humus layer. There was no correlation between soil conditions and fertilizer response. Hoffman and Schlubatis (2) examined the soil profile underlying a raspberry patch to a depth of a little over 6 feet, and determined the nitrate, moisture, and acidity conditions. They report that subsoil condition was the limiting factor in growth and production with raspberries. This factor was chiefly the height of water table. The roots did not penetrate water-logged areas even in summer when the soil was not saturated. In some cases the water table rose in the spring to within 9 inches of the surface. Good locations had a water table over 2 feet below the surface. Nitrates and acidity varied widely, and total soluble material in the soil varied to a considerable extent but under the conditions reported they were not correlated with plant growth or yield.

Wallace (4, 5), Grubb (7), and Hatton and Grubb (8) in their papers on Leaf Scorch refer to conditions that influence the incidence or severity of the trouble. These conditions are usually such that water relations must be acknowledged to play an important part. Some of their observations and data deal with increased scorch on "Dwarf" vs. "Free or Standard" stocks, with heavy cropping, and with increased vegetative growth caused by pruning or nitrogenous fertilizers. Wallace states that this trouble (Scorch) always occurs in conjunction with shallow or dry soils, i.e. under conditions of low moisture supply, whatever the cause may be. Summarizing, he states (5), "The evidence accumulated is all in support of the view that Leaf Scorch results from defective nutrition. Much of it also points directly to the development of Leaf Scorch being brought about by unsatisfactory conditions of water supply within the tissues of the plants".

Wallace and Grubb both report cases where potash manures did not completely control Leaf Scorch although in the majority of trials they did. In all instances, the trouble was greatly reduced by potash applications.

Wallace considers that Scorch is caused by potash deficiency and is directly related to the nitrogen-potash ratio. It is interesting to note that some of the soils on which Scorch occurred had a higher potash content than other soils on which trees were unaffected.

Observations and Data on Tree Condition. Our investigations have not shown that the existing moisture variation had any relation to tree growth. Circumference measurements, both before the experiment commenced and since, fail to reveal any effect on this character. Cropping records also show no differences that could be attributed to tree position in relation to moisture supply. However, only three years' records are available.

No foliage difficulties have been experienced on the plots in the experimental area proper, except the somewhat unhealthy condition previously referred to. In an immediately adjacent area, where other trials were being carried on, Leaf Scorch developed. This is a browning (often resulting in death) of the tips and margins of the leaf, and in extreme cases the whole leaf is affected, resulting finally in partial defoliation of the tree. The trouble has already been exhaustively reported by Wallace (4, 5) and Grubb (7, 8) in England, and later by Stuart (6) in the United States.

The trees referred to had exhibited previous to treatment symptoms which were later associated with restricted moisture supply. The variety was Scarlet Beauty and the trees were similar in all respects to the original experimental material.

There were three treatments: (1) spring applications of ammonium sulphate at the rate of 4 lbs. per tree; (2) similar to group 1 but 2 lbs. per tree; (3) fall applications of nitrate of soda at the rate of 4 lbs. per tree with spring applications as with group 1. Treatment was commenced in the fall of 1931 and records are for 1932. Table 3 summarizes the observations and data. It seems reasonably definite that there is a positive relationship between the quantity of nitrogen given and the development of Leaf Scorch. There is some reason for assuming that a heavy crop accentuates Scorch, although this is not conclusive in the data submitted. The relative amounts of Leaf Scorch present on the trees were not estimated, nor were trees with a few injured leaves classed as Scorch. If any injury was present it usually occurred in considerable amounts. The incidence of the trouble and its spread was not observed in 1932.

Discussion. The soil under investigation is level, perfectly uniform in appearance and reasonably uniform in structure to a depth of 6 - 7 feet. Structural differences, associated with large variations in moisture supply, occur below that depth, much lower than soil investigations are usually carried. Ecological and soil moisture studies have gone much deeper (13, 14). The conditions existing are quite different, as far as the tree is concerned, from cases of shallow soil or variations appearing at no great depth. Most published work deals with the latter conditions. There must be many physiological and horticultural factors, other than water relations, present where roots are restricted, the soil water-logged, or where quickly varying extremes of water supply occur. It cannot be stated that no factors other than water supply are active in the area under discussion but this is at least the factor of major importance. The location is free from aeration and root killing conditions with their many complex effects.

TABLE 3.—*Effect of nitrogen applications on apple foliage.*

	Treatment	Crop		Leaf Scorch	Remarks 1932
		1931	1932 bus.		
Row 1 Tree					
1	F.S.*	0†	6.25‡	No†	Fruit very small, dull.
2	"	0	10	Yes	Hardly worth picking..
3	"	0	7	"	Fruit very small.
4	"	0	7.25	"	" " "
5	"	0	5.25	"	" " "
6	"	0	7.75	No	" " "
7	S	small tree		—	— — —
8		Crop	0	Yes	
9	F.S.	0	3.50	"	Fruit fair.
10	"	0	3.50	"	" "
11	S	Crop	7	"	" "
12	S	"	9.25	"	" "
Row 3 Tree					
1	S½	Crop	3.50	Yes	Fruit small, dull.
2	"	"	0	No	Fairly good.
3	"	"	0	"	" "
4	S	0	6.50	"	" "
5	"	0	0	"	Tree poor condition.
6	"	0	9	"	Fruit good.
7	"	0	6	"	" "
8	"	0	10.50	"	Fruit fairly good.
9	"	0	14	"	Fruit good.
10	"	0	6.25	"	Fruit fairly good.
11	"	0	11.50	Yes	Fruit small dull.
12	"	0	14.50	No	Fruit good.
Row 5 Tree					
1	S½	0	9.50	Yes	Fruit small dull.
2	"	Crop	2	No	Fruit good.
3	"	"	0	"	" "
4	"	"	6	"	" "
5	"	"	0	"	" "
6	"	0	4	"	" "
7	"	0	9.25	"	" "
8	"	Crop	0	"	" "
9	"	0	10.75	"	" "
10	"	0	12.33	"	" "
11	"	0	9.25	"	" "
12	"	0	11	Yes	Fruit small, dull.

*F = Fall; S = Spring; S½ = 2 lbs. per tree, Spring.

†No definite record 1931. Bearing trees had medium to heavy crop.

‡Relative amount of scorch not estimated.

§Measurement to the nearest quarter bushel.

Wallace has definitely established the moisture factor in Leaf Scorch and its increased severity under a high ratio of nitrogen-potash. This investigation bears out his findings. The major emphasis of the former investigations has, however, always been placed on the potassium or nitrogen-potassium relationship. If the temporary, practical aspects of the question are not considered it would appear that the moisture relationship is the primary factor in these types of foliage injury. May it not be that the effects, and their extent, of potash or other minerals is in a large measure controlled by the moisture supply and that Leaf Scorch and parallel conditions should

not be considered as primarily due to mineral deficiencies or balance? Many investigators have demonstrated the importance of the moisture factor in plant metabolism. The complexity of the problem renders it extremely difficult to accurately and definitely determine the cause or causes which operate and the paths they follow.

The amount of water in the soil was stated in the forepart of this paper. There was no sign of wilting of any part of the trees and it would not be reasonable to expect with this soil type that there would be a water deficit at all times. The trees even on the dry areas made good growth when fed with nitrogen. The conditions that have arisen in our work, coupled with the opposite or shallow soil condition investigated by other workers, point to the fundamental importance of factors other than soil type, structure, or geological formation. It is conceivable that one or more of these factors may be frequently correlated with a certain soil type or structural characteristics but this is by no means open to wide application. Relatively minor variations, frequently within a small area from the standpoint of soil investigations, may mean the difference between success and failure as far as the tree is concerned. Field observations where the same fruit and variety is found eminently successful over a wide variety of structural and textural soil types would strongly support the foregoing statements.

Stuart (6) finds nitrate accumulation in the leaves of one year planted trees, and correlated with a type of foliage injury somewhat resembling Scorch. He does not consider this similar to the trouble reported by Wallace and Grubb. The latter work and this investigation included only bearing or reasonably mature trees. Can young trees be considered physiologically comparable to mature or even partially developed trees for, they are certainly not so treated in the orchard? Experience has often proved that comparatively minor changes may prove disastrous to young plants but would have little effect on older material. Is it not possible that the preceeding considerations might make some difference in the position or type of Scorch developed?

SUMMARY

1. Moisture supply has been the main factor in controlling fruit color during the time and under the conditions of this experiment.
2. Fertilizers have had little, if any, effect in improving or reducing color.
3. The moisture differences were established at greater depths than are usually considered in orchard investigations. Work at depth has been confined chiefly to ecological or soil moisture studies.
4. Leaf Scorch at present appears to be primarily a moisture trouble which was accentuated by heavier applications of nitrogen than were desirable under the existing conditions. Potash has as yet shown no marked effect on foliage conditions.

ACKNOWLEDGEMENTS

Mr. M. P. Glover assisted with the soil borings and records, while all the figures were made by Miss L. W. Heringa. The author gratefully acknowledges the help of these members of the Department of Horticulture.

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INVESTIGATIONS ON BLACK KNOT OF PLUMS AND CHERRIES

I. DEVELOPMENT AND DISCHARGE OF SPORES AND EXPERIMENTS IN CONTROL¹

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[Received for publication January 13, 1933]

Black knot is a serious disease of plums and cherries in Ontario, as well as in other parts of the Dominion. During 1928 and 1929 the disease was unusually prevalent and at the request of many growers an intensive investigation of it was begun. The present article gives the results of investigations dealing with: (1) the development and discharge of the ascospores and conidia of *Dibotryon morbosum* (Schw.) T. & S., and, (2) control experiments. The more fundamental investigations regarding the life history of the fungus and other phases of the disease will be published at a later date.

There are no records in the literature giving any precise or detailed information regarding the discharge of ascospores of the black knot fungus, though numerous statements have been made concerning the time of their appearance in the spring. Farlow (3) in 1876 states that he found a few ripe ascospores on January 17th. Crozier (2) in 1884 states that "by March 1st most of the asci contained spores but they were still unripe." Gilbert (5) in 1913 makes the statement that "the perfect stage matures from the 3rd to the 15th of March." Unfortunately, these investigators neglected to mention on which host their observations were made and the criterion by which spores were judged to be mature.

PRODUCTION AND DISSEMINATION OF ASCOSPORES

Until specific information concerning ascospore discharge is obtained, efforts at control must at best be undertaken more or less empirically. Since, however, ascospores appear to be the important source of primary infection under Ontario conditions an investigation of their development and the conditions under which they are discharged and disseminated was undertaken.

EXPERIMENTS IN ORCHARD

To study ascospore discharge outdoors two types of spore traps were used. The first type has been illustrated and described previously (10, p. 266, type B). A modification of this type was also utilized, in which lightly-vaselined microscope slides were maintained by means of small wooden supports at various distances ($\frac{1}{4}$ to $\frac{3}{4}$ inches) from the perithecial stromata of knots on trees in the orchard. A second type consisted of a wind-vane with a wooden crossbar in front made to hold in an upright position five lightly-vaselined slides. In this way the slides always faced the wind. Four

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of these traps were made and placed in trees at each side of the orchard. The slides from the various traps were examined and renewed after each shower and were occasionally examined at other times. The results of these examinations and certain factors relating to ascospore discharge are recorded in Figures 1 and 2. In order to represent ascospore discharge graphically and to correlate it with certain meteorological data, frequency classes were arbitrarily designated in the following way: up to 5 spores per low power field of the microscope (16 mm. objective and 15X eyepiece) were designated as "very light" (v. l.); 5 to 10 spores, (light) (l.); 10 to 25 spores "light heavy" (l.h.); 25 to 50 spores, "heavy" (h.); and more than 50 spores "very heavy" (v.h.). The relative spore discharge as it appears on the graphs for a certain day is always the average obtained from the examination of 22 to 28 slides taken from the first type of spore trap. In consequence, the amounts of the ascospore discharges reported are necessarily only approximate but their value lies in the fact that they are relative.

Judging from the ascospores caught on exposed slides over a period of four years, discharge began on a limited scale towards the end of March, rose gradually to a maximum which was maintained from about the third week in April until the end of May and then dropped rather sharply to relatively insignificant amounts during the first week in June.

From an examination of Figures 1 and 2 it will be observed that in each year after ascospore expulsion has begun no discharge was observed in the absence of precipitation. It will also be observed that the curve of ascospore discharge is more or less uniform in all years. Early in the season, e.g., April 7, 10 and 10 in 1929, 1931 and 1932 respectively, when rainfall was heavy and temperatures were within a favourable range only light spore discharges occurred. On the other hand later in the season, e.g., May 7 and 12, 1929, May 8, 1930 and 1931 and May 7 and 8, 1932 when precipitation was light and temperatures were not limiting factors abundant discharges occurred. The above evidence would seem to indicate that the abundance of ascospore discharge is not determined by the amount of precipitation but by the maturity of the perithecia.

Regarding the influence of temperature on ascospore expulsion, the following evidence is adduced. On April 23, 1931, when the temperature ranged from 36° to 41° F., spore discharge was very light in spite of a heavy rainfall. The same thing occurred on April 26 with temperatures ranging from 36° to 44° F. On the other hand, on April 22 when the temperature ranged from 42° to 68° F., though rainfall was less than on April 23 or 26 the discharge was heavier. Again, on April 26, 1932 with a heavy rainfall and a temperature range of 36° to 40° F., only a very light spore discharge occurred. This also followed heavier discharges on several previous occasions when temperatures were higher and rainfall less.

It will be observed in Figure 1 that the earliest ascospore discharge in 1930 is recorded on April 12 which was between two and three weeks later than in other years. This may be accounted for by the occurrence of a prolonged cold spell during the latter half of March which probably delayed perithecial development, since the maximum temperature rose above 40° F.

on only one day. On March 26 there was a heavy rainfall but spore discharge might have been inhibited in any case by the temperature which ranged from 30° to 35° F. However, there were three rainfalls subsequent to the one on March 26 when temperatures were apparently favourable and yet no spore discharges were observed. On these occasions maturity of the perithecia was probably the predominating factor governing discharge. It must be remembered too, in the above experiments, that the very earliest spore discharge outdoors might easily have been overlooked due to the possibility of not having had the most mature perithecia in the spore traps, or simply due to oversight, because all early discharges were light.

The results obtained from the second type of spore traps in 1932 are summarized in Table 1.

TABLE 1.—*Summary of ascospore discharges obtained in spore traps set up on different sides of plum orchard.*

Location of trap	No. of ascospore discharges observed.	Direction of wind during rainfalls when spore discharges occurred.
East side of orchard	8	West
East side of orchard 30 ft. from nearest plum tree	4	3—West 1—North
North side of orchard	4	3—West 1—South-west
West side of orchard	Nil	
South side of orchard	Nil	

It will be observed in this table that the majority of ascospores were found in traps on the east side of the orchard. The most noteworthy result was that of finding ascospores at a distance of 30 feet from the nearest plum tree. It is not yet possible to explain why the two spore traps on the west and south sides of the orchard should yield negative results since there were both east and north winds during rainfalls within the period of spore discharge.

EXPERIMENTS IN LABORATORY

Knots containing perithecia were brought into the laboratory at frequent intervals throughout the winter to ascertain whether or not they would discharge ascospores earlier under favourable temperature and moisture conditions than they would if allowed to remain in the orchard under natural conditions. Perithecia were also subjected to various temperatures to ascertain their effects on spore discharge.

Portions of the perithecial stromata of knots mature in appearance were stuck to the inside of the top of petri dishes and kept moist continually by contact with small strips of wet blotting paper. A slide with a drop of sterile water spread thinly over its centre was then placed on small supports near the bottom of the petri dish and spore discharges from the perithecia were caught in the water on the slide. Perithecia were also allowed to shoot upwards against a film of water on the under surface of slides but the first method proved more convenient and satisfactory.

In 1931 the earliest immediate discharge from perithecial material on *Prunus domestica* L., brought into the laboratory and treated in the above-mentioned fashion was observed on Feb. 12. These perithecia discharged spores more or less continuously for the subsequent 15 days. From Feb. 12 until June 11 ascospore discharges were observed from all carefully-chosen perithecia which were subjected to laboratory conditions.

In 1932 the earliest ascospore discharge from perithecia in the laboratory was observed on Jan. 30. After that date perithecia which would expel spores were obtained until June 14 when the latest discharge was noted.

Some interesting results were also obtained from the host *P. pennsylvanica* L. Prof. J. G. Coulson of Macdonald College, Quebec, kindly furnished some excellent material on this host. Spore discharges were obtained from these perithecia as early as Nov. 28 in 1931 and Nov. 22 in 1932. In both of the above instances, however, the maturity of the perithecia may possibly have been hastened to a certain extent by the temperatures during transit which were somewhat higher than prevailed outdoors.

It was observed during the course of the two years' experiments that perithecia on *P. domestica* were more numerous and discharged a greater abundance of spores when collected after the end of March than if collected earlier. The majority of perithecia began to discharge ascospores within a few hours after they were subjected to laboratory conditions. Perithecia which required a much longer time to begin discharging spores were not considered to be fully mature on the date on which they were collected. Expulsion of ascospores from mature perithecia usually continued for a period varying from 4 to 16 days.

The following relative spore discharges were obtained by subjecting numerous mature perithecia to various temperatures: at 32° to 35° F., negligible; at 37° to 41° F., light; from 50° to 80° F., very heavy, and at 88° F., and above, negligible.

It might be suggested concerning all of the above findings regarding ascospore discharges that the asci might have discharged immature spores when they were subjected to favourable temperatures and abundant moisture in the laboratory. We cannot say that this does not happen to some extent though there is no good reason to believe that it should occur. In most cases, even of the earliest discharges reported, a few cultures of the black knot organism were obtained when ascospores were plated out. It is difficult even with the most mature material to obtain a small percentage of ascospores of *D. morbosum* which will germinate and continue growth in artificial medium.

The laboratory experiments on ascospore discharge, in addition to confirming evidence submitted for natural outdoor conditions with respect to temperature and moisture, indicate that some perithecia on *P. domestica* are sufficiently mature in some years to discharge ascospores considerably earlier than actually occurs in nature.

PRODUCTION AND DISSEMINATION OF CONIDIA

While these investigations indicate that conidia of *D. morbosum* are not as important in producing infection as ascospores, they are, nevertheless, an important phase of the life history of the organism. It is essential to ascertain

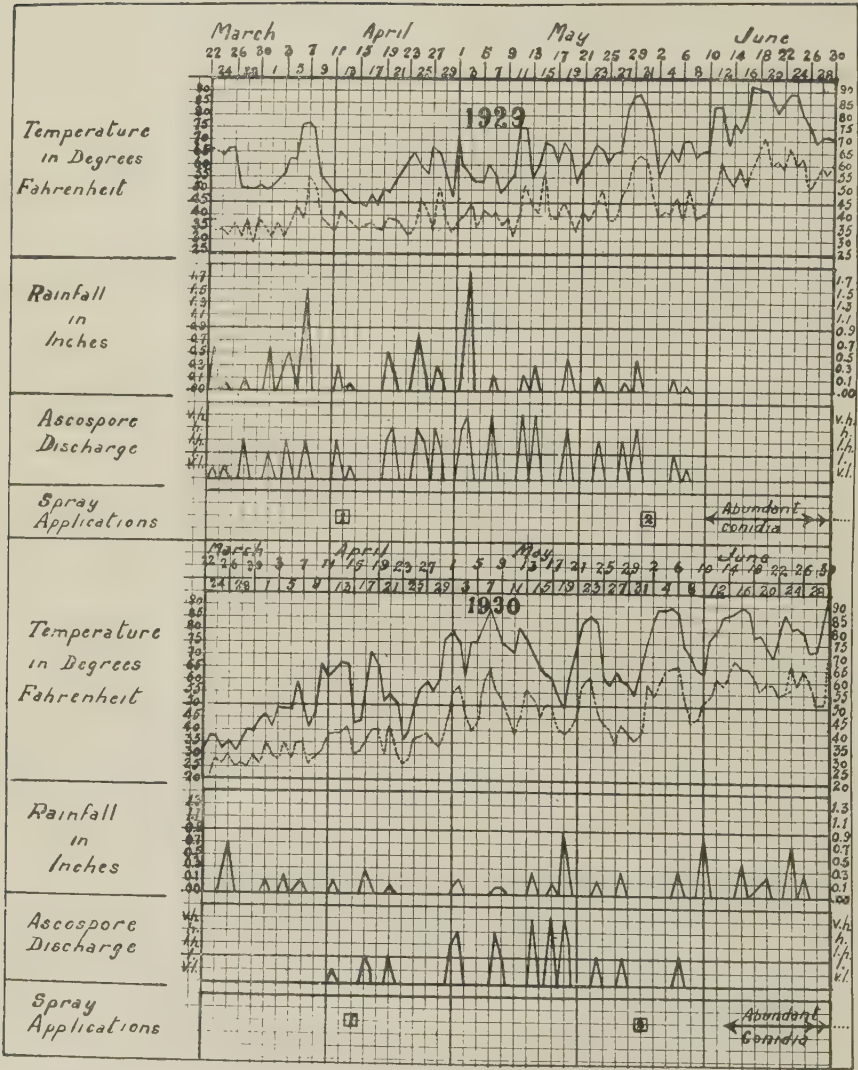


Figure 1. Graphic summary showing the relation of temperature and rainfall to the period and amount of ascospore discharge, as well as dates of spray applications and periods of conidial development in 1929 and 1930.

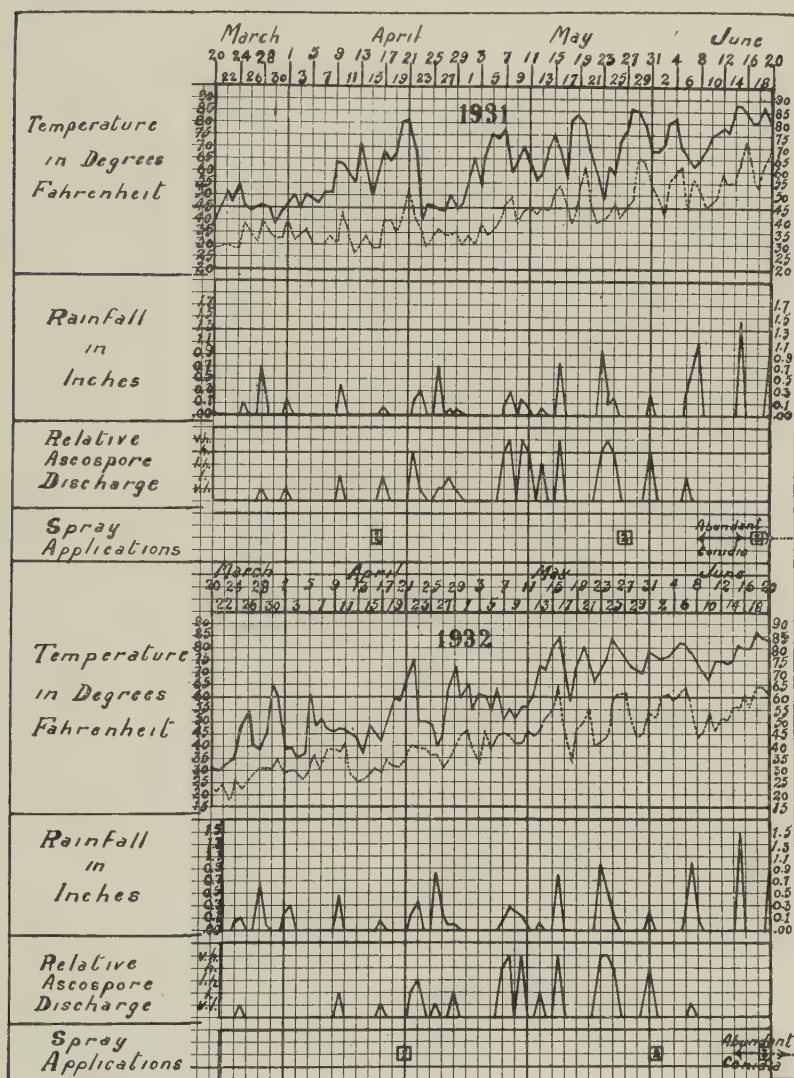


Figure 2. Graphic summary showing the relation of temperature and rainfall to the period and amount of ascospore discharge, as well as dates of spray applications and periods of conidial development in 1931 and 1932.

therefore, when the conidia become mature and the part they play in initiating knots.

An examination of Figures 1 and 2 shows that in four summers during which close observations of conidial development were made, abundant conidia were first present on the young knots on trees of *Prunus domestica* from June 8 to June 12. Earliest conidia appeared approximately a week sooner. It is interesting to note that in all four years abundant conidia were present at, or shortly after, the time when ascospore discharge ceased. In the Georgian Bay district abundant conidia were always present a week or more earlier than in the Niagara Peninsula on the same host. Mature conidia were abundant on *P. pennsylvanica* earlier in Quebec than on *P. domestica* in the Niagara peninsula and have been observed on all hosts in abundance during June, July and August.

On various occasions in June 1931 conidia were observed on slides taken from the wind-vane type of spore traps stationed in an unsprayed tree in block D (see Table 2) which contained numerous knots. They were observed, however, in most cases only after rainfalls and their numbers varied greatly. After high winds without rains only negligible numbers were found on a few occasions.

Sporulating knots bearing an abundance of conidia on their surfaces were then brought into the laboratory and subjected to strong currents of air. Conidia which were dislodged as a result of this treatment were caught on vaselined slides. Numerous attempts showed that relatively few spores were caught in this way unless the current of air was very strong, in which cases conidiophores along with conidia were dislodged and caught on the slides. On the other hand, when a wire loop containing a drop of water was

TABLE 2.—Summary of pruning and spraying treatments to control black knot of plums.

Block	No. of trees	Year	Date of pruning	Spray applications
A	22	1929	Nil	1 & 2
		1930-32	Nil	1, 2 & 3
B	9	1929	Feb. 21	2
		1930-32	Feb. 21	2 & 3
C	9	1929	Mar. 22	1 & 2
		1930-31	Mar. 26	1, 2 & 3
		1932	Mar. 27	1 & 2
D	9	1929-32	Nil	Nil
E	9	1929	Feb. 21	1
		1930-32	Feb. 22	1 & 3
F	8	1929	Feb. 21	1 & 2
		1930-32	Feb. 22	1, 2 & 3
G	9	1929	Feb. 23	1 & 2
		1930-32	Feb. 22	1, 2 & 3
H	9	1929-30	Feb. 21	1 & 2
		1931-32	Feb. 21	1, 2 & 3

touched lightly to the sporulating surface of a knot and removed, an abundance of spores was observed to be present in the drop. Again, when microtome sections of the conidial stroma were cut and examined without the addition of water, it was found that a large number of conidia remained attached to the conidiophores, but on the addition of a drop of water the majority of them immediately became detached.

The above evidence would seem to indicate, therefore, that the most important factors in the dissemination of the conidia of the black knot fungus are probably moisture in conjunction with wind. It might be pointed out that this evidence is in accordance with that found by Frey and Keitt (4) working with *Venturia inaequalis* (Cke.) Wint.

TABLE 3.—Summary of results of pruning and spraying experiments to control black knot of plums.

Block	Year	No. of knots	Percentage control
A	1929	61	....
	1930	127	80.0
	1931	139	78.2
	1932	185	83.8
B	1929	10	....
	1930	110	54.0
	1931	40	85.0
	1932	36	91.0
C	1929	60	....
	1930	94	61.0
	1931	21	92.0
	1932	12	97.0
D	1929	61	Nil
	1930	300	Nil
	1931	566	Nil
	1932	1016	Nil
E	1929	42	....
	1930	21	92.1
	1931	23	91.0
	1932	63	86.0
F	1929	57	....
	1930	21	91.0
	1931	11	97.0
	1932	6	98.0
G	1929	46	....
	1930	36	85.0
	1931	36	86.2
	1932	47	89.6
H	1929	24	....
	1930	40	84.0
	1931	11	95.8
	1932	44	90.9

CONTROL EXPERIMENTS

Control of black knot was investigated by Lodeman (11) in 1897. He attained a measure of success by a combined pruning and spraying schedule carried out under New York conditions. Present control measures seem to be based on the results he obtained, and on experience, as no intensive investigations dealing with this phase appear to have been reported since that time.

PRUNING AND SPRAYING

Our control experiments were all carried out in the laboratory orchard which consists of eighty-four mature trees of the Lombard variety. Rows ran north and south. Block A was at the extreme east end of the orchard and H was at the extreme west end. The check block, D, was situated in the centre of the orchard. The various pruning and spraying treatments to which the different blocks were subjected for four years are summarized in Table 2. In blocks B, C, E and F branches which contained knots were always pruned about four inches below the base of the swelling. In blocks G and H affected branches were pruned at the immediate base of the visible knot. All spraying was carried out with a power sprayer at a pressure of 250 lbs



Figure 3. Tree in block C (adjacent to block D) which received both pruning and spraying treatments for four years. Photograph taken Nov. 30, 1932.

In Table 2 spray applications are designated by the numbers 1, 2 and 3 according to time of application. Spray No. 1 was a delayed dormant spray usually applied in April. Spray No. 2 was applied at about the time the shucks fell which was usually about the end of May, shortly before earliest conidia appeared on young knots, and spray No. 3 was applied several weeks later. The delayed dormant spray consisted of a 3% lubricating oil emulsion with 3: 6: 40 Bordeaux mixture, or of a 1: 8 lime sulphur mixture, blocks A, C, E and H receiving the former and blocks F and H the latter. All

later sprays consisted of 1: 40 lime sulphur. The results obtained in the various blocks as a result of the above-mentioned pruning and spraying investigations are summarized in Table 3.



Figure 4. Tree in block D which received neither pruning nor spraying for four years. Photograph taken Nov. 30, 1932.

It will be observed that no percentage control figures appear for the year 1929. These were omitted because of the fact that many knots resulting from current season infections do not become readily visible or produce spores until the following year, and consequently the results of one year's spraying and pruning are not totally manifested until the subsequent year.

An examination of Table 3 yields some interesting information. The highest percentage of control was obtained in block F which received regular pruning combined with a complete spray schedule. In this block control for three years averaged 95.5%. In block C which received the same treatments, control was equally good with the exception of the year 1930. However, this block of trees was

adjacent to and on the east side of the heavily infested block D, and thereby was probably subjected to more inoculum, as indicated previously in Table 1, than any other sprayed block in the orchard. Relatively good control was obtained in blocks G and H considering that a large number of the knots which were pruned at the immediate base of the swellings continued to extend their boundaries the following year. It was found that during a period of three years the percentage of knots pruned in the above fashion which continued to extend their boundaries the following year varied from 26 to 92. An average of 89% control was obtained in block E which received no second (shuck) spray. This is considerably less than that obtained in the adjacent block F, which received similar pruning treatment and one additional spray. Similarly, poorer control was consistently obtained in

block B which received no delayed dormant spray, than in blocks C and F which did receive it. Regarding later sprays, nothing definite can be gleaned from the table. No apparent difference in results was obtained between those blocks which received a dormant application consisting of a 3% oil emulsion with a 3: 6: 40 Bordeaux mixture and those which received a 1: 8 lime sulphur.

A noteworthy feature of the above experiments was the rapid increase in the number of knots in block D where no pruning or spraying operations were carried on (see Figures 3 and 4). In four years the number of knots increased 1655%.

SURGICAL EXPERIMENTS

For the past two years surgical experiments have been carried on in an effort to remove knots which had become established on large branches and trunks of plum trees in such a way that they could not be pruned out without causing serious injury to the tree. Knots chosen for these experiments were in most instances 3 or 4 years old, on trees of the Lombard variety. All visible knotted tissue was cut out except in three instances where the old, central portion of the knot was allowed to remain. Even where the tissues were obviously knotted excision was not made much deeper than in the surrounding layers of external xylem. All tissues external to the xylem and as far as one-half inch beyond the visible knot were removed. Figure 5 gives an illustration of a typical knot used in these experiments before and after excision. Table 4 gives a summary of the experiments and the results obtained.

TABLE 4.—*Summary of surgical experiments to remove knots from large branches and trunks of plum trees.*

Block	Date of experiment	No. of knots cleaned out	Treatment	Re-development of knots	Callus formation
C	26.3.31	5	5 percent Agrisol	None	Good
D	1.11.31	5	Untreated	None	Fair
B	2.4.32	2	5 per cent Agrisol	None	Fair
C	2.4.32	2	Untreated	None	Excellent
D	2.4.32	1	Untreated	None	Excellent
D	8.7.32	5	Vultex paste*	None	Excellent

*Vultex is a vulcanized rubber paste manufactured by the Sterling Rubber Company of Canada.

It will be observed in Table 4 that all knot excisions which were attempted proved successful. In no case did any wound show the resumption of knot growth to date, whether untreated or otherwise. A 5% Agrisol solution always appeared to cause a measure of killing of the tissue to which it was applied. Good callus formation resulted both when the excisions were made early in the spring and left untreated, and also when made late in the summer and covered with Vultex paste. Studies on the histological phase of this disease lead us to believe that in the case of large knots with irregular borders, successful removal can be accomplished by cutting out a minimum of tissue beyond the boundary of the visible knot, provided that the operation is performed in July or August. It would appear to be preferable to protect the wound with a compound such as Vultex paste

which appears to aid callus formation if the removal is made at the above-mentioned time, but, on the other hand, if done early in the growing season callus formation seems to be accomplished rapidly and well if wounds are left unprotected.

CONTROL MEASURES

The above control experiments, in addition to certain unpublished data on other phases of the disease lead us to suggest the following control measures for black knot in Ontario.

1. All knots should be removed from cultivated trees preferably during the winter or before growth in the spring is resumed in order to prevent infection of young twigs by spores which mature on the knots during the winter. Excisions should always be made approximately four inches below the base of the visible swelling. If the pruning is done early in the season the pruning cut can be safely made closer to the base of the visible swelling than if performed later, or after growth begins. During the latter part of May a second inspection should be given the orchard in order to remove those knots which were not visible in the winter but which swell rapidly in the spring and produce conidia.

2. All knots which are pruned out should be burned immediately because if allowed to remain on the ground mature ascospores capable of causing infection will develop in them.

3. When knots develop on large limbs or trunks the knotted tissue should be carefully removed, approximately as far as one-half inch beyond the boundary of the knot. It is not necessary to remove much xylem even beneath the visibly-knotted areas.



Figure 5. Photograph showing knot infection of main limb of plum tree, (A) before, and (B) after surgical treatment, Aug. 2, 1932.

4. All thickets of wild plums and cherries adjacent to cultivated orchards should be removed.

5. A delayed dormant spray consisting of either a 3% oil emulsion with 3: 6: 40 Bordeaux mixture, or lime sulphur (1: 8) as well as at least one other spray consisting of lime sulphur (1: 40) should be applied before the conidia mature.

DISCUSSION AND CONCLUSIONS

The results of the experiments dealing with ascospore discharge both outdoors and in the laboratory would appear to justify certain conclusions. Firstly, it appears that active discharge of ascospores of *D. morbosum* will occur only when knots bearing perithecia are wet. This has also been found to be true by Keitt and Jones (9), and Chamberlain (1) for *Venturia inaequalis* (Cke.) Wint., by Heald and Walton (7) for *Endothia parasitica* (Murr.) And., and by many other investigators of Ascomycetes. Secondly, temperature appears to reduce the abundance of ascospore discharge, provided it drops below approximately 40° F., other influencing factors being favourable for discharge. Most abundant ascospore discharges occur both outside and from perithecia brought into the laboratory when temperatures are above 40° F., and below 80° F. A third conclusion to be drawn from these experiments is the fact that maturity of the ascospores appears to be the predominating factor determining the abundance of ascospore discharges, but it does not appear to be the only factor governing the date of the earliest spore discharge outdoors. Apparently neither ascospores nor conidia of *D. morbosum* mature at the same time in different localities on the same or on different hosts.

The results obtained from the second type of spore trap prove that ascospores and conidia of *D. morbosum* are wind-borne, which is in accordance with what has been found by Heald, Gardner and Studhalter (6), for *Endothia parasitica* (Murr.) And., and by Keitt and Jones (9), Howitt and Evans (8), and others, for *Venturia inaequalis* (Cke.) Wint. It would seem that moisture and wind are the two most important factors governing dissemination of conidia.

The results of the control experiments indicate that a combined pruning and spraying programme is necessary to control black knot. Pruning is essential because of the fact that knots are perennial and in those trees which receive no pruning for several years knots soon develop on the larger branches, thereby making proper pruning on these trees difficult, if not impossible, in the future. Apparently all knots should be pruned some distance below the base of the swellings to ensure discontinuance of the mycelial growth down the branch. The success obtained in the surgical experiments should simplify considerably the pruning of trees in which knots have become established on large branches and main trunks.

An outstanding feature of the spraying experiments and one which throws new light on control of black knot, is the apparent importance of both the delayed dormant, or first spray, which was applied at the time the buds burst in the spring, and the second spray which was applied about the time the shucks were falling. These results bear out the findings in the spore development studies (see Figures 1 and 2), namely, that the bulk of the ascospores were not discharged until some time in May, which was subsequent

to the application of the dormant spray, and that the conidia were not mature in abundance until June, or shortly after the time when the second spray was applied.

SUMMARY

1. Over a period of four years under natural orchard environment the initial ascospore discharge from perithecia of *Dibotryon morbosum* (Sch.) T. & S. on *Prunus domestica* L., in the Niagara Peninsula varied from March 23 to April 6, after which discharges occurred periodically until June 6 or June 7. Perithecia which were brought into the laboratory from the same trees and moistened, discharged ascospores one month and a half earlier than discharges were observed in the orchard. Perithecia from *P. pennsylvanica* L. discharged ascospores as early as Nov. 20 in 1931 under laboratory conditions.

2. Rainfall appeared to be the predominating factor determining the occurrence of ascospore discharge in the orchard, but, on the other hand, did not seem to determine its abundance.

3. Temperatures below 40° F., appeared to reduce ascospore expulsion in the orchard and in the laboratory. In the laboratory abundant spore discharges were observed at temperatures of 50° up to 80° F.

4. Maturity of the perithecia appeared to govern the abundance of ascospore expulsions during May but did not seem to entirely determine the date of earliest spore discharges.

5. Ascospores of *D. morbosum* proved to be wind-borne. They were found in spore traps 30 feet from the nearest plum tree subsequent to rainfall.

6. Conidia of *D. morbosum* were present in abundance on knots on *P. domestica* at the time ascospore discharge ceased, and continued to be produced throughout the summer. Moisture and wind appeared to be the most important factors in the dissemination of conidia.

7. In a block of Lombard plum trees which was neither sprayed nor pruned, the number of knots increased 1655% within a period of three years. More than 95% control was obtained in blocks of trees subjected to a combined programme of pruning and the application of a dormant spray consisting of either 3% oil emulsion Bordeaux or 1: 8 lime sulphur, followed by two later sprays consisting of 1: 40 lime sulphur. The first spray which was applied at about the time the buds were breaking and the second spray applied when the shucks were falling, appeared to be important in controlling the disease.

8. Knots on large branches and trunks of Lombard plum trees were successfully removed by surgical methods.

ACKNOWLEDGEMENT

Thanks are gratefully extended to Dr G. H. Berkeley for many helpful suggestions throughout the course of this investigation.

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AUTOGAMOUS ALFALFA

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[Received for publication April 27, 1933]

Alfalfa plants normally do not set seed freely unless the flowers are tripped. The tripping may be effected artificially or naturally. Natural fertilization is accomplished by the visitation of insects or as the result of atmospheric conditions which are sufficiently favourable to cause the tripping mechanism to act spontaneously. Atmospheric conditions in the greenhouse, especially during the winter season, are less favourable to spontaneous tripping of the flowers than those which sometimes obtain in the open. For this reason alfalfa plants in a greenhouse, even when daylight is supplemented by the best artificial light, rarely set seed.

In the winter of 1930-31, and to a lesser extent in previous years, large numbers of alfalfa plants were propagated in a greenhouse. One of these produced a good crop of pods without the aid of artificial manipulation. Six successive seed crops have been harvested from this plant, no care having been taken to maintain suitable conditions for seed setting. During that time the proportion of flowers which produced pods has varied from 40 to 60%.

During 1931-32 additional plants of the same variety were grown and a second plant was secured which produced pods freely up to 60% of the total number of flowers.

Large numbers of plants were again propagated in 1932-33. Of these, two plants produced 50 - 60% of pods, two gave 60 - 70%, one 80 - 90% and another 96%.

An interesting thing about these self-fertilizing plants of alfalfa is that tripping of the flowers is not necessary for fertilization. In all cases the pollen is shed in the early bud stage of flower development and it is deposited on the stigma in abundance. This fact, however, cannot be regarded as a satisfactory explanation as to why certain plants are capable of self-fertilization, because it is now realized that the anthers of ordinary alfalfa plants also dehisce in the bud stage. Apparently also it is not a question as to whether or not pollen is deposited on the stigma since this occurs normally in both cases. The interesting problem is being investigated as to precisely why a few plants are capable of self-fertilization and produce a full crop of seed while the generality of plants produce no pods in the greenhouse or very few without artificial tripping of the flowers.

Seed setting in alfalfa, although affected by many factors, undoubtedly is dependent, to a considerable extent, on tripping of the flowers. It has long been believed that the mechanism of tripping constituted the means by which the anthers were ruptured and pollen brought into contact with the stigma. Observations by the writers and other workers indicate that the pollen is shed quite generally before the flowers are tripped. Coffman (1) dissected the flowers under a binocular and concluded that "practically all alfalfa

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blossoms shed their pollen in the pointed bud stage and before the hooded bud stage is reached." Engelbert (2) stated that she "found alfalfa flowers carefully handled and examined in the field practically always showed the anthers dehiscent and the stigma covered or partly covered by pollen."

In our experiments to determine whether or not the anthers have dehiscent before tripping and at what stage of flower development this takes place, it was found very difficult to make observations by any method of examination that necessitated dissecting or partly opening the flowers without running the risk of rupturing the anthers. A method was sought, therefore, by which the flowers could be made transparent and a technique which has proven very successful was finally evolved. The treatment may be described as follows.

Racemes of flowers are first frozen to destroy the tension of the tripping mechanism. It has been demonstrated that this does not cause the anthers to dehiscent. After they have thawed, the flowers are placed on a microscope slide. Each flower is then treated with two drops of a solution consisting of equal parts of hydrogen peroxide, 95% ethyl alcohol and a concentrated solution of chloral hydrate. In five to fifteen minutes, when the color is almost completely bleached out, the standard is removed by holding the flower between the thumb and finger and pulling the standard vertically downward with tweezers. The wings are then folded back and the flower returned to the slide when a drop of 95% alcohol is applied, followed by a drop of cedar clearing oil. Each flower is then examined with a binocular microscope against a black background. Light is supplied from a bulb without reflector placed under and slightly in front of the stage. A 45 m.m. objective and No. 4 oculars provide a satisfactory magnification.

All of these self-fertilizing plants were obtained from a selection of Grimm alfalfa designated Sask. No. 666 (*Medicago sativa* var. *media*). This variety was developed by the senior author at the University of Saskatchewan, the original selection having been chosen from 1300 clonal rows because of its high seed yield.

In a communication from the Superintendent, Uintah Basin Alfalfa Seed Experimental Farm, State Agricultural Experiment Station, Logan, Utah, Mr. J. W. Carlson states that a selection out of Grimm Sask. No. 666 "has proved to be a consistently good seeder and the best we have found in our trials to date." The data for two seasons from replicated plots shows that the strain in question yielded almost double the local variety which was used as a check. It seems probable that this selection owes its prolific seeding habits to some degree of the same inheritance possessed by the self-fertilizing plants referred to above, since both had their origin in a common line of descent.

It seems probably that most cultivated varieties of alfalfa contain a small proportion of autogamous plants. These can be discovered only by growing large populations to maturity in a greenhouse which is screened to exclude insect pollinators. A small group of selected autogamous individuals should provide valuable material on which to base a program of breeding for seed production.



Figure 1. Alfalfa plants grown to maturity in a greenhouse during the winter season. Right—Autogamous alfalfa plant with full crop of seed pods. Left—One of fifty check plants showing almost total absence of pods.

SUMMARY

Several autogamous alfalfa plants have been found which produce a full quota of seed pods under greenhouse conditions. Pollination takes place in the early bud stage and fertilization does not require that the flowers shall be tripped. They differ from the generality of alfalfa plants which normally do not set seed under similiar conditions unless the flowers are tripped. It is considered probable that such autogamous plants occur fairly frequently in the cultivated varieties of *Medicago sativa*.

A method of rendering the petals of alfalfa flowers transparent is described which was used to determine by examination the exact stage of flower development at which pollination takes place.

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O.A.C. GRADUATE BECOMES MASTER FARMER

The first holder of the B.S.A. degree in Canada to be honoured with the title of Master Farmer is Percy E. French of Vernon, B.C., a graduate of the Ontario Agricultural College in 1911. Mr. French operates a splendid mixed farm in the Okanagan Valley. In the fall of 1930 we had the pleasure of eating MacIntosh apples direct from the tree in his orchard and wished that we could stay long enough to have sirloin steak from the Shorthorns which roamed the pasture below. Not only were the farm operations a joy to behold, but the home was one of the most attractive that we have ever seen. Mr. French, who was an active member of the student body at Guelph and made a good reputation as a hockey player, has followed up by taking an active part in British Columbia organizations for the improvement of agriculture. This honour, awarded through the competitions sponsored by the "Nor-West Farmer" of Winnipeg, is well deserved and technical agriculturists are pleased to know that we have at least one man in our ranks who can hold his own with the best farmers of the Dominion.

THE TOMATO ROOT KNOT DISEASE

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[Received for publication January 23, 1933]

The tomato root-knot disease caused by the nematode species *Heterodera radiculicola* (Geef.) Muller, and characterized by numerous knots or galls on the fibrous roots is responsible for large annual losses to the greenhouses growers of tomatoes in British Columbia. Most authorities agree that steam sterilization of greenhouse soils once every three or four years is the most economical means of controlling this disease. Unfortunately very few greenhouses in B.C. are steam heated. The smaller greenhouse operators cannot afford to install an additional boiler and purchase the necessary steam hose and grid for soil sterilization purposes. To control root knot these growers are forced to depend upon the complete removal and replacement of their greenhouse soil or upon sterilization by chemical means. In an attempt to assist these growers an investigation was conducted upon the influence of chemicals added to soil infested with nematodes. A 1% formalin solution was found to be an effective control measure.

EXPERIMENTAL

Tomato seed was sown in four inch pots filled with uniform quantities of soil known to be infested with root-knot nematode. To ensure a surplus amount of inoculum, a quantity of chopped knots or galls was added to each pot. The results are given in the Table 1.

TABLE 1.—*The influence of chemicals upon the growth of tomato plants when sown on nematode infested soil. (150 cc. solution, or specified amount solid: 500 g. soil.)*

Treatment	Seeds planted	Seedlings produced	Number damped	Growth index 1-10	Percentage infection
None	60	36	6	3	100
Acetic acid 2% soln.	30	12	0	8	100
Ammonium sulphide 2% soln.	All seedlings died.				
Chlorinated lime 2.5% soln.	30	29	2	6	100
Cyanogas, 5 g.	60	15	4	6	80
Formalin 1% soln.	50	50	0	10	0
Formalin .5% soln.	30	30	0	8	100
Formalin .25% soln.	30	30	0	8	100
Soln. of formalin .12% and KMnO ₄ .12%	30	29	7	9	100
Formalin dust 50% 4 g.	30	16	0	8	90
Javelle water 2.5% soln.	30	0	0	0	0
Lead arsenate 4 g.	30	10	3	4	100
Lime 5 g. and sulphur 5 g.	30	23	0	5	30
Mercuric cyanide 1% soln.	30	0	0	0	0
Phenol 1% soln.	30	11	0	4	10
Potassium cyanide 2% soln.	30	13	0	9	75
Potassium permanganate 2.5% soln.	30	17	0	9	100
Potassium sulphate 2% soln.	30	26	2	4	100
Silver nitrate 0.1% soln.	All seedlings died.				
Sodium sulphide 1% soln.	30	8	5	3	100
Soil dried 3 weeks in dry atmosphere	30	21	2	5	40

¹ Pathologist-in-charge and Plant Disease Investigator, respectively.

From the data given, it is evident that a 1% formalin solution (a 0.4% formaldehyde solution) was the only effective chemical under test in the control of the root-knot nematode. Unfortunately the cost of disinfecting soil with formalin is high. Calculated from these experiments 1 gallon of commercial formalin (100 gallons of solution) will effectively sterilize 50 cubic feet of soil. An interesting feature of formalin sterilization is that it appeared to markedly stimulate the growth of the seedlings. The experimental data with respect to 1% formalin reveal that seed germination was perfect and the growth index was the maximum. However, at the concentrations below 1% the formalin did not prevent infection. The experiments revealed that tomato seed can be sown without danger immediately after a soil is treated with formalin.

Other compounds lowered the incidence of infection but no other treatment completely prevented nematode infection.

SUMMARY

A 1% formalin solution (a 0.4% formaldehyde solution) effectively controlled the root-knot nematode and appeared to stimulate the growth of the seedlings. Lower concentrations, 0.5% and 0.25% were not effective in preventing infection. Calculated from the experiments, one gallon of commercial formalin (100 gallons of solution) will effectively sterilize 50 cubic feet of soil.

Other compounds lowered the incidence of infection but did not effectively prevent infection.

AGRICULTURE GETS RHODES SCHOLARSHIP

The first Rhodes Scholarship awarded to an agricultural student in Canada has been given to Wm. J. Garnett, B.S.A., of the 1932 class of the Ontario Agricultural College. Mr. Garnett was born in Cheshire, England, and attended Charterhouse School from 1923 to 1926. In 1926 he came to Canada to engage in farming and entered the degree course at Guelph. In 1929 he was awarded the Governor General's silver medal for general proficiency and also the George Chapman Prize for work in English literature. In 1931 he received the '05 class prize for the best all-round man in his year. We first met him as Editor of the O. A. C. Review and appreciated his qualities for that position. Throughout his course at Guelph he took an active interest in athletics, being captain of both the inter-faculty soccer team and the harrier team of the College. He also served as Assistant Dean of Mills Hall. Rhodes scholarships have come rarely, if ever, to agricultural students and it is a great satisfaction to know that Canada will have a man of Mr. Garnett's accomplishments to represent us at Oxford University.

CONSIDERATIONS HISTORIQUES SUR LES LAITS DE FERMENTATION ACIDE ET SUR LEUR FLORE MICROBIENNE*

F. G. CORMINBOEUF

Dans cette étude préliminaire, nous nous proposons de développer successivement les points suivants:

- I.—Les produits lactés de fermentation acide dans l'histoire de l'humanité.
- II.—Historique des recherches bactériologiques et chimiques sur la flore microbienne du Yoghourt et du lait acidophile.
- III.—Historique des recherches relatives aux propriétés thérapeutiques de la flore microbienne du Yoghourt et du lait acidophile.

II.—HISTORIQUE DES RECHERCHES BACTERIOLOGIQUES ET CHIMIQUES SUR LA FLORE MICROBIENNE DU YOGHOURT ET DU LAIT ACIDOPHILE.

L'étude morphologique et physiologique déterminative des divers microorganismes qui opèrent la fermentation lactique ou alcoolique du lait pour le transformer en Yoghourt, Kéfir, Koumiss ou produits similaires, a fait l'objet de travaux considérables dès le début du XX^{ième} siècle. Les conclusions des recherches effectuées jusqu'à date devaient nous apprendre, en ce qui concerne le Yoghourt, que la flore microbienne de celui-ci peut être très variée, mais que le produit considéré comme étant normal au point de vue des qualités organoleptiques, résulte de l'activité symbiotique de trois types de bactéries lactiques associées en parties égales. La symbiose se compose alors du *Thermobacterium Yoghourtii* (Jensen), du *Thermobacterium bulgaricum* (*Bacillus bulgaricus*, Grigoroff) et du *Streptococcus thermophilus* (Jensen). Bien que ces trois types de microorganismes soient les agents nécessaires et suffisants pour l'obtention d'un Yoghourt de bonne qualité, on leur associe parfois, et pour certaines raisons particulières que nous examinerons plus loin, le *Streptococcus lactis* (Lister), Löhnis, ou le *Bacillus acidophilus* (Moro). Dans ce dernier cas, la préparation fermentée porte le nom de Yoghourt-acidophile ou de Yoghourt réformé. Mais il arrive fréquemment que le *B. acidophilus* (*Lactobacillus acidophilus*) soit cultivé seul dans le lait pour donner un produit connu sous les noms de "Lait acidophile" ou "Acidophilus Milk", ou encore "Lactobacillus acidophilus Milk". Ceci nous conduit donc à considérer essentiellement dans cette partie historique les recherches bactériologiques et biochimiques qui se trouvent en relation avec les cinq types de ferments ci-dessus mentionnés.

Notons tout d'abord qu'en 1902, Rist et Khoury (58) isolent pour la première fois du Leben égyptien, un streptocoque, un bacille grêle, un diplocoque et deux levures, qu'ils nomment respectivement *Streptobacillus lebenis*, *Bacillus lebenis*, *Diplococcus lebenis*, *Saccharomyces* et *Mycoderma lebenis*.

Les recherches se poursuivant, trois ans tard, Grigoroff et Cohendy (23) identifient des organismes similaires dans un lait bulgare. En 1906, Dügge (15) trouve dans le Mazun ou Madzoon des Arméniens des ferments lactiques

* Préliminaires d'une étude expérimentale sur "Les caractères Biochimiques des Microorganismes du Yoghourt et du Lait acidophile" poursuivie aux laboratoires de biochimie de la Faculté des Sciences de l'Université de Montreal et de l'Institut Agricole d'Oka.

sous forme de bâtonnets, les uns longs, les autres courts, que Weigmann (65) identifie en 1907, sous les noms respectifs de *Bacterium mazum* et de *Bacillus mazun*. La même année, Samarini (61) trouve dans le Gioddu ou Cieddu, lait fermenté de Sardaigne, deux organismes correspondant, l'un au *Bacillus casei* de Freudenberg (18), l'autre, au *Bacterium lactis acidi* de Leichmann (47).

Quelques années plus tard, Gorini (21) isole d'un Skorup un lactobacille accompagné d'une levure et d'un streptocoque lactique.

Enfin, Troili-Peterson (62) décrit sous le nom de *Bacterium lactis longi* un organisme isolé du tâttemjôlk, qu'il considère comme l'agent actif de la fermentation de ce produit. C'est un streptocoque qui ressemble au *Bacterium lactis acidi*, mais il développe moins d'acidité, et donne au lait une consistance visqueuse. L'auteur rapporte que cet organisme est incapable de produire un tâttemjôlk normal, même avec les feuilles de *Pinguicula* et de *Drosera* qui entrent habituellement dans cette préparation lactée. D'après Heineman (26) la fermentation du tâttemjôlk serait due à trois organismes distincts:

1. *Un streptocoque lactique* qui diffère du *Streptococcus lactis* en coagulant le lait plus lentement et en produisant une substance étrange;

2. *Une levure* ayant la morphologie du *Saccharomyces cerevisiae*, et qui communique un arôme caractéristique. En cultures pures, cette levure fermente le lactose et le sucrose, avec formation d'un gaz violent; avec le lévulose, la production de gaz est lente, tandis qu'avec le maltose, il ne s'en forme pas du tout;

3. *Un oidium lactique* qui développerait selon toute probabilité la saveur et l'arôme de ce produit rappelant le fromage.

Le Streptobacille de Rist et Khoury, le Lactobacille de Grigoroff et de Cohendy, et celui de Gorini, furent reconnus en 1910 par Makrinoff (50) comme étant des bactéries à peu près identiques, qu'on désigne fréquemment aujourd'hui par les synonymes de *Bacillus bulgaricus*, *Lactobacillus bulgaricus* ou *Bacterium bulgaricum*.

Ajoutons que ces types de bactéries appartiennent au groupe *Plocamobacterium*, Löwi 1920, Lehmann et Neumann 1923-1927, correspondant d'après Beyerinck (1901) et Bergey au groupe des Lactobacilles ou suivant d'autres auteurs, à celui des bactéries longues de l'acide lactique.

En référant à Jensen, Kunze, Löhnis, Lassar, Weigmann, Henneberg, Weingartenel, Rosell, Bergey etc, les principales caractéristiques du genre sont les suivantes: bâtonnets cylindriques, généralement longs mesurant de 0.2 à 15 microns, avec ou sans granulations métachromatiques, sans spores, ni flagella. Ils sont dénués de mouvements propres, Gram-positif, acidophiles (4). Ils développent habituellement une forte acidité, et croissent de préférence en milieux aérobies; résistent très bien à la chaleur et assez bien à la dessiccation; se cultivent généralement avec difficulté dans les milieux de culture ordinaires. Leur température de développement est maximum à 50°C environ, optimum entre 38 et 42°C. Ajoutons encore que les vieilles cultures ainsi que celles qui proviennent de lieux éloignés ont une tendance manifeste à croître en filaments allongés, atteignant parfois 50 microns ou plus. Ces formes dégénérées doivent être réensemencées en lait peptoné

pendant plusieurs jours consécutifs, pour reprendre leurs caractères morphologiques et physiologiques normaux.

Jensen (35) démontra l'existence de deux types de *B. bulgaricus* qui se distinguent notamment par l'absence ou la présence de granulations métachromatiques (volutine) après leur coloration par la technique au bleu de méthylène de Loeffler, ou celle de Gram. L'un, le *Thermobacterium Yoghourtii* ou *Tbm. jugurt* (Jensen) (34) correspond d'après Henneberg (29) à l'organisme généralement décrit sous le nom de *B. bulgaricus*. Il ne forme pas de granulations métachromatiques et il constitue d'après les recherches de l'auteur, l'agent le plus actif du Yoghourt, développant dans la formation de ce produit jusqu'à 1.5% d'acide lactique racémique. A 42°C, il coagule le lait en 3 ou 4 heures. Au cours de nos expériences, nous avons pu constater qu'à ce moment, le lait possède un pH de 5.3 environ et une acidité totale de 21 à 24° Soxhlet-Henckel. Selon Jensen (36) le *Thermobacterium helveticum* du fromage Emmenthal présente avec lui beaucoup d'analogie. La principale différence réside dans leur action sur le maltose; alors que le premier fermente ce sucre distinctement, le second ne le fermente que légèrement. Le *Thermobacterium helveticum* trouvé dans l'intestin humain partage avec le *Tbm. Yoghourtii*, certaines propriétés importantes, entre autres, celles de produire de l'acide lactique inactif et de ne former aucune granulation de volutine.

L'autre type, le *Thermobacterium bulgaricum* (Jensen) forme contrairement au *Tbm. Yoghurtii* des granulations de volutine, particulièrement nombreuses en cultures jeunes. Mais d'après Rosell (60) dans le Yoghourt frais, ces granulations sont rarement observées, si bien que pour en déceler la présence plus sûrement, il convient de réensemencer les cultures en lait de 24 à 28 heures, sur "beerwort" additionné de lactose. Il ne fermente pas le maltose et développe comparativement une faible quantité d'acide lactique dans le lait; environ 1.7% comme maximum (de plus cet acide est lévogyre); tandis que le *Tbm. Yoghurtii* pourrait développer jusqu'à 3.5% d'acide inactif (30).

Cependant, ces deux types possèdent, comme on devait s'y attendre, certaines propriétés communes. Ainsi, d'après Jensen (37), ils clivent la caséine et ne fermentent pas le saccharose, et selon Henneberg (31) leur température de développement est maximum à 50°C environ, optimum entre 38 et 42°C. Par ailleurs, Rahe (55) distingue en se basant sur la fermentation des glucides, les 4 types suivants de *B. bulgaricus*:

Types	Maltose	Lactose	Saccharose	Raffinose
A	—	+	—	—
B	—	+	—	+
C	—	+	+	—
D	—	+	+	+

Avec Rahe, plusieurs auteurs reconnaissent à certains types de *B. bulgaricus*, le pouvoir de fermenter le saccharose. Mais Löhnis (60) les considère comme intermédiaires entre le *B. bulgaricus* et le *L. acidophilus* typiques.

Le *B. bulgaricus* se développe ainsi que nous l'avons déjà fait remarquer très difficilement sur la plupart des milieux artificiels, à moins que ceux-ci renferment du lait, du petit-lait ou de l'extrait de malt. Son milieu de

culture par excellence est le lait, mais encore faut-il que celui-ci réponde à certaines conditions. Ainsi, Laxa (44) faisait remarquer en 1921 que l'observation faite autrefois par Weiggert et Wolff de Kiel, à savoir que cet organisme pousse difficilement dans certains laits, peut s'expliquer par l'âge du lait. En effet, ce dernier en provenance de la campagne peut contenir déjà des produits microbicides qui atténuent sa vitalité. Dans un même ordre d'idées, mentionnons que le *B. bulgaricus* est très sensible aux variations naturelles du lait. L'expérience journalière démontre que certains laits normaux à l'aspect comme à l'examen chimique et micrographique, se révèlent pourtant plus ou moins dysgénésiques vis-à-vis du *B. bulgaricus*. Rappelons avec Gorini (20) que ces insuffisances culturelles sont dues vraisemblablement à la carence naturelle ou à la destruction d'un "quid" qui se comporterait un peu à la façon des vitamines. Par ailleurs, le lait provenant de vaches affectées de la mammite, et même celui qui ne contient qu'une faible proportion de germes mastitiques, présentent habituellement des insuffisances culturelles vis-à-vis des bactéries du Yoghourt.

Comme le lait accuse dans ce cas-là, une augmentation du pH, de sa teneur en chlore et en germes endogènes, les inconvénients observés pourraient donc être attribués à une action inhibitrice ou restrictive des chlorures ou de la micro-flore mammaire.

La température de conservation des cultures possède également une influence marquée sur la vitalité du *B. bulgaricus*. Laxa (45) a pu constater sur une culture bien préparée que la vitalité se conserve d'une semaine à un mois, et cela dépendait principalement de la température ambiante. En effet, à 8°C, elle se conservait un mois, à 10-15°C, deux semaines, et à 15-20°C, une semaine seulement. L'auteur confirma également l'observation faite par Paulak vers 1920, à savoir, que la vigueur du *B. bulgaricus* est prolongée en présence de levures du genre *Torula*. La symbiose de ces deux organismes, à l'étuve à 35°C, lui donna encore après un mois, un Yoghourt d'excellente qualité. L'auteur ne peut cependant conclure que la présence de cette levure soit indispensable à la préparation d'un produit normal, Disons tout de suite, que dans la préparation courante de Yoghourt, les levures constituent les agents infectants les plus communs. Dans ces conditions, le Yoghourt présente toujours des défauts, tant sous le rapport de la texture que sous celui de la saveur et de l'arôme. Les levures généralement rencontrées dans ces infections sont les *Saccharomyces*, et les *Mycoderma*. Leur rôle est encore assez mal connu. On sait cependant qu'elles forment diverses substances aromatisées et de l'alcool dont la proportion toujours faible est limitée par la température élevée de l'incubation.

En étudiant l'influence de l'*Oidium lactis* sur la caséine, Grimmer (24) et ses collaborateurs trouvèrent principalement parmi les produits de clivage, les acides oxy-phényllactique, oxy-phénylacétique, propionique et succinique.

Quant au bacille grêle de Rist et Khoury (58) on sait maintenant qu'il n'appartient pas à la micro-flore normale du Yoghourt, mais qu'il est l'agent principal de la fermentation du Kéfir. Il fut observé pour la première fois, en 1881, par Kern (40) qui le nomma à tort, ainsi que Krannhals (43) 1884, *Dispora caucasica*. Beyerinck (12) en 1889, puis Freudenreich en 1896 (19) décriront sous les noms respectifs de *Bacillus causicus*, et de *Bacterium causicum*, des bactéries lactiques peu mobiles, formatrices de gaz, isolées

du Kéfir et ressemblant par leurs caractères essentiels au lactobacille que Grigoroff découvrit plus tard dans le lait bulgare. Si la description de Freudenreich (19) reste exacte, le *B. caucasicus* se distinguerait donc du *B. bulgaricus* par sa propriété de fermenter le lactose avec dégagement de gaz, ainsi que par sa faible motilité. Cependant, le Kéfir ne constitue pas pour le *B. caucasicus*, le seul habitat naturel convenable. Les recherches de Heine-man et Hefferan (27) montrèrent que cet organisme n'est pas particulier aux laits fermentés, comme on l'avait cru tout d'abord, mais qu'il est répandu un peu partout. En effet, ces auteurs l'ont isolé du lait, de la salive, de divers aliments acides, du sol et des matières fécales.

En ce qui concerne le diplococoque de Rist et Khoury, de Grigoroff et de Cohendy, il s'est révélé très semblable, sinon identique, au *Bacterium lactis acidi* Leichmann, synonyme du *Str. lactis* (Lister) Löhnis, et du *Str. acidi lactici* de Grotenfeld, que Samarini isole du Gioddu et 1907. D'après Grigoroff (22) la température optimum de croissance de cet organisme est d'environ 35°C, et dans cette condition, il coagule le lait au bout de 7 à 8 heures.

Le *Str. lactis* accompagne quelquefois le *Thermobacterium bulgaricum* dans le Yoghourt, et habituellement dans le lait bulgare, mais il ne paraît pas essentiel à la fermentation de ce produit; il jouerait un rôle adjuvant au début de la fermentation, en empêchant la contamination du milieu. Ceci pourrait s'expliquer par le fait que la température optimum de développement de cet organisme dans le lait, se trouve bien inférieure à celle du *Tbm. bulgaricum*; elle est en effet, d'après Weigmann (64) comprise entre 30 et 35°C.

En 1920, Marshall (51) étudia la symbiose du *Strept. lactis* avec le *Bacillus subtilis* dans le lait, et arriva à la conclusion que la présence de ce dernier avait pour effet d'activer la fermentation lactique du *Strept. lactis* et notamment à basse température et aux premiers stades de la fermentation.

Tout récemment Porcher et Lambert (54) ont également démontré que le *B. subtilis* exerce un effet stimulant sur le *Str. lactis* et qu'en fait, il accélère la coagulation du lait. Enfin, une influence stimulante sur le *Str. lactis* a été observée par Barthel (2) pour le *Penicilium glaucum* et pour les espèces *Mucor* et *Aspergillus* et par Leitch (48) pour l'*Oidium lactis*.

Pour obtenir un Yoghourt de haute qualité, on associe aux ferments bulgariques, une variété du *Streptococcus lactis* décrite par Orla-Jensen (34) sous le nom de *Str. thermophilus*, de préférence au *Str. lactis*. Ce ferment montre une meilleure croissance sur le lait réduit par l'évaporation. Il développe environ 0.5% d'acide lactique dans le lait et améliore considérablement l'arôme du Yoghourt. Sa température optimum de développement varie entre 38 et 44°C, et sa température maximum est supérieure à 50°C. Dans les conditions optimales, il peut coaguler le lait en 3 - 5 heures. Ceci est un point important pour le différencier du *Str. lactis* ordinaire lequel n'opère la coagulation qu'au bout de 20 à 24 heures. Il fermente le lactose, le lévulose, le mannose et le galactose; quelques races attaquent aussi le saccharose (6). Ces sucres sont également acidifiés par le *Str. lactis* et le *Str. cremoris*.

D'après les recherches de Henneberg (30) sa symbiose avec les ferments bulgariques est des plus faciles à réaliser.

Quant au *Bacillus acidophilus*, ou *Bacterium acidophilum* des auteurs allemands, il fut isolé pour la première fois par Moro vers 1900 (52) sous la dénomination de *Bacillus acidophilus*. Il correspond à l'organisme classé par Orla-Jensen dans le groupe des *Microbacterium* et décrit par lui sous le nom de *Microbacterium lacticum* (36). Le *Lactobacillus acidophilus* est l'agent unique de la fermentation du lait acidophile, et prend une part importante dans la symbiose du Yoghourt-acidophile (Reform-Yoghourt).

Rahe distingue 4 types de *L. acidophilus*, en se basant sur la fermentation des glucides: (56)

Types	Maltose	Dextrose	Lactose	Saccharose	Raffinose
A	+	+	+	+	+
B	+	+	+	+	—
C	+	+	—	+	—
D	+	+	—	—	—

Il se distingue donc des bacilles du Yoghourt proprement dit, par son action sur les glucides; il fermente contrairement au *Tbm. Yoghourtii* et au *Tbm. bulgaricum*, le maltose distinctement, et le saccharose avec production d'acide lactique. De plus, certaines de ses variétés attaquent également la dextrine. Des différences de tension superficielle ont été observées par Albus et Holm (1), par Kopeloff et Beermann (42).

Au cours de nos expériences, nous avons pu observer qu'il forme un caillé plus visqueux que les bacilles bulgariques, et moins visqueux que le *Str. thermophilus*.

Il possède en commun avec le *Tbm. bulgaricum*, la propriété caractéristique de former des granulations métachromatiques (volutine). Sa température optimum de développement est de 37°C, mais il résiste à une température très élevée (thermorésistant). Il peut supporter, en effet, 80 à 85°C, de sorte qu'on le retrouve parfois dans le lait pasteurisé, sous la forme de culture pratiquement pure (Orla-Jensen). Il clive la caséine, mais sans lui faire subir de profondes modifications chimiques (49). Lorsqu'il est inoculé dans le lait stérilisé (bouilli), il développe pendant les deux premiers jours, comparativement moins d'acidité que les deux bacilles du Yoghourt, et pour cette raison, la période nécessaire à la coagulation de la caséine est plus longue. D'après Henneberg (32) il forme en lait stérile, pendant 3 jours à 37°C, de 44 à 46.8°S.H. d'acide lactique, tandis que dans les mêmes conditions le *Tbm. Yoghourtii* et le *Tbm. bulgaricum* en donnent respectivement 104.8°S.H. et 51.2 à 53°S.H.

Ajoutons que le *Lactobacillus acidophilus* est micro-aérophile, et qu'au point de vue morphologique, il se distingue très difficilement du *Tbm. bulgaricum* car il forme également des bâtonnets longs, dénués de mouvements propres, et Gram-positif.

Considérons maintenant de façon plus spéciale les recherches relatives aux modifications chimiques opérées par nos lactobacilles, principalement en milieux lactés. Les premiers travaux scientifiques dirigés dans cette voie furent effectués par Rist et Khoury en 1902 (58) date à laquelle ils décelèrent dans le *Leben* égyptien, la présence des 5 organismes plus haut mentionnés. Ces auteurs remarquent tout d'abord que le *Streptobacillus lebenis* (*B. bul-*

garicus) produit de l'acide lactique et fait coaguler le lait par l'action combinée de cet acide et de la présure qu'il secrète. Ils constatent également que cet organisme rend le lactose fermentescible pour le *Saccharomyces* et le *Mycoderma* qui l'accompagnent et que ces deux levures donnent lieu à la production d'alcool et autres composés mal définis, qui communiquent au caillé, son arôme. Pour ce qui concerne l'activité du bacille grêle, le *Bacillus lebenis* (*B. caucasicus*) les auteurs notent qu'il forme une petite quantité d'acide que le *Streptobacillus lebenis*. Par ailleurs, ils remarquent que son absence dans le Leben n'entraîne apparemment aucune différence, dans les propriétés du produit. En terminant leur communiqué, les auteurs attirent l'attention sur une propriété biologique intéressante: à savoir que ces bactéries ne croissent que sur des milieux sucrés; propriété, qui "est le meilleur argument que l'on puisse donner en faveur de leur spécificité; spécificité acquise par l'accoutumance prolongée à un même milieu, le lait."

En 1906, Guerbet (25) ayant examiné la micro-flore de certaines échantillons de Yoghourt, la trouve identique à celle que Rist et Khoury avait étudié dans le Leben; de plus, il observe la même concordance au sujet de la composition chimique et des propriétés organoleptiques des deux produits lactés. Par contre, il considérerait comme hypothétique la déclaration de Rist et Khoury, suivant laquelle l'alcool procéderait de l'action des levures, sur du galactose formé aux dépens du lactose.

Se proposant d'apporter de nouveaux faits, Guerbet conduit une expérience sur du yoghourt de 3 origines: le premier échantillon renfermait les 5 organismes antérieurement décrits (58), les deux autres, préparés avec une levure sèche ne renfermaient que le Streptobacille et le diplocoque. La fermentation étant effectuée à température constante, et suivie d'un refroidissement rapide, l'auteur voit disparaître le *Saccharomyces* et le *Mycoderma* d'abord, puis le bacille grêle après quelques réensemencements. Enfin, le diplocoque meurt à son tour, seul le streptobacille résiste bien. Alors Guerbet, entreprend l'expérience suivante: Il cultive en lait carbonaté, le *Streptobacillus lebenis* d'une part, cet organisme avec des levures d'autre part. Après une incubation de 3 jours à 40°C, les milieux sont analysés pour l'acidité totale et l'alcool, et donnent les résultats suivants:

	Culture du <i>Strep. lebenis</i>	Culture du <i>Str. lebenis</i> et levures
Acidité totale en $C_3H_5O_3$	0.99%	1.25%
Alcool	0.15%	0.18%

De ces résultats, l'auteur conclut 1.—Que l'alcool est d'origine bacillaire. 2.—Que le streptobacille est suffisant pour assurer la fabrication du Yoghourt. C'est un fait reconnu aujourd'hui que le *Streptobacillus lebenis* (*B. bulgaricus*) ne produit pas d'alcool (10).

G. Bertrand et G. Weisweiler (11) après avoir étudié l'influence du ferment bulgare sur le lait, fournissent en 1907, les résultats qui suivent: le ferment bulgare (*B. bulgaricus*) est le plus actif des organismes qui transforment le sucre en acide. Il solubilise environ 10% de la caséine, mais il n'en utilise seulement qu'une petite quantité pour son développement. Il produit une très légère saponification de la matière grasse. L'action du

ferment sur le lactose est par contre très énergique, et avec l'aide d'une lactase, il convertit pratiquement tout le sucre de lait en un mélange d'acide lactique, lévogyre et dextrogyre dans lequel ce dernier prédomine. Il se forme également, environ 0.5 gramme d'acide succinique par litre, et à peu près la même quantité d'acide acétique. Cet organisme est considéré comme le premier ferment lactique connu, pour produire de l'acide succinique et pour hydrolyser une quantité aussi considérable de lactose avant de le convertir en acide lactique.

Les mêmes auteurs (10) avaient établi dès 1906 qu'il ne se formait pas d'acétone, ou d'alcool, ni d'acétylméthylcarbinol dans le lait bulgare.

En 1909, Bertrand et Duchacek (9) confirment les résultats sus-mentionnés et constatent la formation d'une petite quantité d'acide formique. De plus (8) en étudiant l'action du ferment bulgare sur les principaux sucres en milieux artificiels, ils découvrent 1.—que parmi les sucres réducteurs non hydrolysables: le glucose, le mannose, le galactose et le lévulose, sont fermentescibles, tandis que l'arabinose, le xylose, le sorbose ne le sont pas; 2.—que parmi les sucres hydrolysables, le lactose seul, est fermentescible; le saccharose et le maltose résistent; 3.—que la mannite n'est pas transformée en acide lactique; 4.—que les produits de fermentation sont les mêmes avec toutes les espèces de glucides fermentescibles et sont identiques à ceux qui prennent naissance dans le lait par la fermentation du lactose. Il y a toutefois, disent-ils une différence d'ordre qualitatif au sujet de l'acide lactique; ainsi, en milieu artificiel cet acide s'y trouve en mélange racémique, tandis que dans le lait, le mélange est dextrogyre. Les auteurs pensent que l'action biochimique du *B. bulgaricus* sur les glucides fermentescibles est absolument comparable à celle qu'exerceraient sur eux certains réactifs chimiques, tels que les alcalis. Seulement, tandis que le mélange racémique subsiste en milieu artificiel, une partie de l'acide gauche ou bien des deux acides, mais alors, du gauche plus vite que du droit, disparaît dans le milieu naturel. Les auteurs (8) ajoutent au sujet des diastases saccharolytiques, que le ferment bulgare ne produit ni sucrase, ni maltase, de sorte qu'il ne peut s'attaquer ni au saccharose ni au maltose; il produit seulement de la lactase et cette production est endocellulaire.

En 1911, Effront (16) ayant isolé d'une lactobacilline commerciale, un microorganisme douée d'une action protéolytique très intense, croit à une variation biochimique de *B. bulgaricus* et attribue les effets thérapeutiques du Yoghourt à cette action plutôt qu'à la formation d'acide lactique.

Mais deux ans plus tard, Duchacek (14) s'occupe de cette question et reconnaît qu'il ne s'agit point d'une variation de ce ferment, mais plutôt d'un organisme différent. Voici le parallélisme qu'il établit entre les caractères de ces deux microorganismes:

Ferment bulgare.

Ferment d'Effront.

Ne donne pas de spores.
Se développe dans l'épaisseur du liquide.
Donne acide lactique racémique.

Donne une petite quantité d'acides volatils et d'acide succinique.

Donne des spores.
Exige eau peptonée etc. . . .
Donne acide lactique droit, avec 50% du lactose disparu.
Donne 4 fois plus d'acides volatils et 10 fois plus d'acide succinique.

Acidité dans le lait égale à 25-30 grammes d'acide lactique.	. . . 4 à 5 grammes d'acide lactique.
Détruit complètement le lactose en présence de craie.	On retrouve du lactose après deux ans de culture.
Coagule la caséine et ne la modifie plus par la suite.	Coagule la caséine puis dissout rapidement le coagulum.

Il s'agissait évidemment d'une lactobacilline infectée, et à en juger par la description de Duchacek, l'agent infectant était selon toute vraisemblance, le *B. subtilis*.

Enfin, plusieurs chercheurs, entre autres, Kayser, Belonowsky, Laxa etc. . . s'occupèrent de l'influence exercée par divers agents tels que: l'acidité, la température etc. . . sur l'activité des ferments lactiques.

D'après Kayser (39) la fermentation lactique en général est favorisée par le CaCO_3 . L'addition de cette substance facilite l'activité des organismes, laquelle se manifeste par une augmentation des acides volatils, mais non pas, de l'acide lactique proprement dit. Dans un même ordre d'idées, mentionnons l'expérience de Belonowsky. L'auteur démontra qu'une souche de *B. bulgaricus* qui se conservait pendant 19 jours à la température de la chambre, pouvait vivre à la suite d'une addition de CaCO_3 de 0.8% et de 4%, respectivement 38 jours et 120 jours.

Enfin Laxa (45) qui prépara depuis 1910 du Yoghourt avec succès au moyen de cultures pures, livrées par l'Institut Lactologique de Prague, relate les observations intéressantes qui suivent: "une température trop élevée provoque un affaiblissement de l'acidification, tandis qu'une acidification trop forte entraîne une diminution de la coagulation."

Quant à la composition du yoghourt, elle est très variable. Elle varie évidemment avec la composition du lait employé, le mode de fabrication, le degré d'évaporation, la durée d'incubation etc. . . la qualité et la composition de la flore microbienne etc. . .

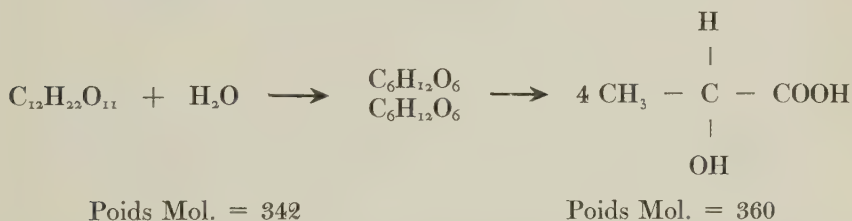
Malgré cela, elle diffère toujours sensiblement de la composition du lait qui a servi à la préparation du yoghourt. En effet, celui-ci renferme toujours, en marge des constituants normaux du lait, des substances comme les albumoses, les peptones, l'acide lactique etc. . . qui ne sont jamais secrétés par la glande mammaire. Pour se rendre compte de ces différences, nous mettons ci-dessous, en parallèle, les résultats moyens de plusieurs analyses de lait et de yoghourts, effectués par divers auteurs.

	I. Lait normal (LeCoq) (46)	II. Yoghourt (Hohenadel) (33)	III. Yoghourt. (Decker) (13)
Protéines (Caséine et albumine).....	3.00 à 3.50	4.98	.....
Matières grasses.....	3.20 à 4.00	2.70 à 3.50	7.00
Lactose.....	4.30 à 5.20	2.40	9.00
Mat. minérale.....	0.60 à 0.80	1.38	1.38
Albumoses et peptone....	.....	0.75	.....
Acide lactique.....	.....	2.50 à 3.50	0.80
Alcool.....	.....	0.20	0.20
Protéines solubles.....	.....	13.00 des protéines totales.	40.00% des protéines totales.

En comparant les tableaux II et III au tableau I, l'on remarque à première vue que les deux yoghourts contiennent des protéines solubles, de l'acide lactique et de l'alcool; substances qui n'existent pas dans le lait normal. A la suite d'un examen plus minutieux, l'on constate que les solides totaux des yoghourts sont notablement plus élevés que ceux du lait. Ils sont en effet, représentés par les moyennes respectives de 12.5, 15.8 et 25.38. Ce fait doit être attribué à l'évaporation qui d'ailleurs, est beaucoup plus prononcée dans le cas du Yoghourt III. En examinant en détail, les chiffres des tableaux II et III, l'on se rend compte, et plus facilement encore, après avoir corrigé les résultats pour l'évaporation, que la quantité de lactose est d'autant moindre que celle d'acide lactique est plus grande. En outre, l'on peut observer qu'il n'y a pas de relation entre les proportions de protéines solubilisées et les quantités d'acide lactique présent. En effectuant les corrections théoriques sur la base des solides totaux (ceux-ci sont considérés comme étant peu variables), l'on obtient les termes suivants qui se prêtent mieux à comparaison.

	I	II	III
Lactose.....	4.8 à 5.2	$12.5 \times 2.4/15.8 = 1.9$	$12.5 \times 9.0/25.4 = 4.3$
Acide lactique		$12.5 \times 3.0/15.8 = 2.3$	$12.5 \times 0.8/25.4 = 0.4$
		Ce qui donne 4.2	Ce qui donne 4.7
Protéines solubles....		13% des prot. totales,	40% des prot. totales.

Il est facile de se rendre compte que la somme des poids du lactose et de l'acide lactique du yoghourt, est à peu de chose près, égale au poids du lactose du lait non transformé. Or, d'après l'équation qui traduit la conversion par voie hydrolytique, du lactose en acide lactique:



la somme des poids du lactose non transformé et de l'acide lactique produit devrait être supérieure au poids du lactose mis en oeuvre par le métabolisme bactérien. Comme la différence observée est au contraire, légèrement inférieure et que de plus, elle se rapporte à des résultats moyens, elle doit être attribuée à la production d'une petite quantité de substances qui ne figurent pas dans cette équation. Ce petit "quid" est peut-être de l'alcool qui a pour origine le lactose, ou encore, de l'acétylméthylcarbinol qui se formerait par désintégration du méthylglyoxal, en acide oxy-pyruvique et en aldol, et par isomérisation de ce dernier.

Quant à la solubilisation des protéines, on ne saurait l'imputer d'emblée à l'action déminéralisante de l'acide lactique sur le complexe phosphocaseinate de calcium, comme on le fait généralement, puisque dans les Yoghourts qui dosent 2.3% et 0.4% d'acide lactique, les proportions des protéines totales solubilisées sont respectivement de 13% et de 40%. Il y eut dans ce dernier cas, (Yoghourt III) vraisemblablement addition d'une substance neutralisante dans le but de prolonger l'activité des ferments

lactiques. Cette neutralisation aurait sûrement favorisé la fonction peptonisante des acidoprotéolytes et augmenté par cela même, la proportion des protéines solubles.

Ces quelques dernières considérations sont évidemment hypothétiques. Elles doivent néanmoins solliciter toute notre attention, en raison de l'intérêt immense qu'elles présentent au point de vue de la chimie du métabolisme bactérien. Dans ce but, nous examinerons ces hypothèses au cours d'un prochain exposé sur une étude expérimentale envisagée à la lumière des faits acquis, particulièrement par Neuberg, Kluver, King, Porcher et Tapernoux.

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NOTES SUR L'ETIOLOGIE DE L'HEMATURIE CHRONIQUE DES BOVIDES. Par Wm. H. Hill, H. M. King, et D. G. Laird, Université de la Colombie Britannique.

Cette maladie est assez commune dans certains districts de la Colombie Britannique. Elle se caractérise par le passage d'urine sanguinolante et cause des pertes considérables d'animaux dans les zones infectées. Elle se rencontre sur les fermes au sol appauvri, acide, lavé par les eaux de drainage, manquant de phosphate, d'azote et de matière organique. L'herbe y contient une grande quantité de silice et d'alumine. La cause de la maladie est probablement un trouble de la nutrition provenant soit de substances ingérées par l'animal, soit de substance élaborées dans le système digestif pendant le métabolisme. Des recherches plus approfondies sont nécessaires notamment sur la composition de l'urine, de la vessie, de la viande et du sang des animaux malade.

RECHERCHES SUR LES CAUSES DE LA MALADIE PROVOQUEE PAR LE MELILOT. J. M. Brown, A. Savage, A. D. Robinson, Collège Agricole du Manitoba, Winnipeg, Man.

Il ne semble pas y avoir de rapports entre la maladie causée par le mélilot (trèfle d'odeur) et le calcium ou le phosphore. La croyance générale que seul le mélilot moisi peut causer la maladie n'a pas été vérifiée par nos expériences. Bien au contraire dans nos expériences la maladie a été provoquée chez les sujets en leur donnant du mélilot très peu moisi. De plus, du mélilot très moisi inoculé artificiellement avec une moisissure provenant du mélilot pathogène n'a pas provoqué la maladie. Le mélilot capable de produire la maladie semble posséder typiquement une coloration brun foncé et une odeur rapellant celle du tabac.

INFLUENCE DES DIFFERENCES D'HUMIDITE DU SOL SUR LA COULEUR DE LA POMME ET LA CONDITION DU POMM ER. D. A. Kimball, Collège Agricole de l'Ontario, Guelph, Ont.

L'humidité a été le facteur principal influençant la couleur du fruit pendant le temps et dans les conditions de cette expérience. Les engrais chimiques n'ont eu que peu ou pas d'effet sur la couleur. Les différences d'humidité ont été établies à de plus grandes profondeurs que ce n'est généralement le cas dans les recherches sur vergers. Il semble que la brûlure de la feuille (leaf scorch) soit principalement due à des conditions d'humidité, la maladie étant d'ailleurs accentuée par de trop fortes applications d'azote. Jusqu'ici la potasse n'a eu aucun effet sur la condition du feuillage.

RECHERCHES SUR LA MALADIE DU "BLACK KNOT" DES PRUNIERIERS ET CERISIERS. L. W. Koch, Laboratoire fédéral de Pathologie Végétale, St. Catharines, Ont.

Des ascospores de *D. Morbosum* ont été déchargées dans la Péninsule du Niagara depuis le 23 mars jusqu'au 7 juin. Une température inférieure à 40°F réduit la décharge, et la quantité de pluie semble le principal facteur influençant la fréquence de la décharge mais non son abondance. Des ascospores ont été transportées par le vent jusqu'à 30 pieds. Dans un bloc de pruniers Lombard qui n'a été ni pulvérisé ni taillé le nombre de noeuds a augmenté de 1655% dans une période de trois ans. Le contrôle de la maladie dans 95% des cas a été obtenu dans des blocs d'arbres convenablement taillés recevant en hiver une pulvérisation à la bouille bordelaise à 3% ou à la chaux soufrée 1: 8 et recevant plus tard deux pulvérisations à la chaux soufrée 1: 40. La première de ces pulvérisations est faite à l'éclosion des bourgeons et la seconde au moment où l'enveloppe des bourgeons tombe. Les noeuds se trouvant sur de grosses branches ou des troncs des pruniers Lombard ont pu être enlevés par des méthodes chirurgicales.

LUZERNE AUTOGAME. L. E. Kirk, Ferme Expérimentale Centrale, et W. J. White, Université de la Saskatchewan, Saskatoon.

Plusieurs pieds autogames de luzerne ont été trouvés qui ont produit en serre une quantité normale de gousses. La pollinisation a lieu dans le bourgeon et la fertilisation se produit sans que les parties sexuelles des fleurs ne soient touchées par les insectes ou stimulées par les conditions atmosphériques ("tripping"). Généralement les pieds de luzerne ne produisent pas de graines dans des conditions similaires à moins que la fécondation de leurs fleurs ne soit ainsi effectuée mécaniquement.

Il est probable que de pareils pieds autogames se rencontrent assez fréquemment dans les variétés cultivées de *Medicago sativa*. Les auteurs décrivent une méthode pour rendre transparentes les pétales des fleurs de luzerne. Cette méthode a été utilisée pour déterminer par l'examen direct à quel stage exact du développement de la fleur la pollinisation se produit.

LA MALADIE DE LA RACINE GONFLEE DES TOMATES. (ROOT KNOT). W. Newton et J. E. Bosher, Laboratoire fédéral de Pathologie Végétale, Saanichton, C.-B.

Une solution de formalin à 1% (solution de 0.4% de formaldéhyde) a enrayé d'une façon efficace, le nematode de la racine gonflée des tomates et a paru stimuler la pousse des pieds de tomates. Les concentrations plus faibles, 0.5% et 0.25%, n'ont pas réussi à prévenir l'infection. D'après un calcul basé sur ces expériences, un gallon de formaline commerciale (100 gallons de solution) suffit pour stériliser parfaitement 50 pieds cubes de terre. D'autres composés ont abaissé la fréquence de l'infection mais ne l'ont pas prévenue.

CONCERNING THE C.S.T.A.

C.S.T.A. SECRETARY WINS CARNEGIE SCHOLARSHIP

Mr. Donald Cameron, B.S.A., Secretary of the North Alberta Branch of the C. S. T. A. has been awarded the Carnegie Scholarship open to Canadian students of rural life for the study of Scandinavian Folk High Schools. This scholarship is given by the Carnegie Corporation of New York through the American Association for Adult Education. The recipient will spend three months in Scandinavian countries studying the system of folk high schools which have created so much interest in Canada and United States. Mr. Cameron graduated from the University of Alberta in 1930. He was active in his student years and is well known throughout Alberta for his work in the Extension Department of the University. He is a son of Donald Cameron, M.L.A., for Innisfail. He is leaving for Europe in May.

C. S. T. A. ELECTIONS

Ballots for the election of officers of the C. S. T. A. for the year 1933-34 were opened at the Society headquarters in Ottawa on May 1st. A total of 692 members voted. Hon. Dr. A. Godbout, Minister of Agriculture for the Province of Quebec and formerly Professor of Animal Husbandry at the Agricultural School, Ste. Anne de la Pocatiere was elected President by acclamation. Mr. L. H. Newman, Dominion Cerealists, Ottawa, and Rev. Fr. Leopold, Director of the Oka Agricultural Institute, La Trappe, P.Q., were elected Vice-Presidents. Mr. Geo. H. Clark, Dominion Seed Commissioner, was elected Honorary Secretary by acclamation. These officers will be installed at the close of the annual convention in Regina on July 24th.

C. S. T. A. MOVES HEADQUARTERS

In company with many other organizations, the C. S. T. A. has been considering the problem of overhead charges and has been trying to locate suitable rooms in Ottawa which can be maintained without too heavy a drain on the resources of the Society during the next few years. During the past five years headquarters rental has been financed by a group of manufacturers interested in agriculture. The funds from this source run out this year and the matter of replacing this revenue under present conditions has been a cause of considerable concern.

A happy solution of the matter has been made possible through the kindness of Mr. F. W. Runge of the Runge Press, Ottawa, printers of *Scientific Agriculture*. Office and lounge room space has been made available in the Runge Building at a rental which the Society should be able to finance without difficulty. The quarters are conveniently located in the down-town section and offer several advantages over the previous quarters. We have slightly more space than we had before, we are in the building where our magazine is printed, we are on the second floor and not dependent on elevator service, and there is ample parking space available for members cars. The move was made just previous to the first of May and the office staff is finding the new arrangement very convenient. The location is 128 Queen Street which is four blocks from the Union Station and the Chateau Laurier, two blocks from the Parliament Buildings and three blocks from the Confederation Building where the Dominion Department of Agriculture is located.

NOTES AND NEWS

D. F. Putman (Toronto 27) is engaged in graduate study in the Department of Botany, University of Toronto and is also acting as Graduate Assistant in Botany. Mr. Putman originally went to the University of Toronto as one of the T. Eaton scholars.

John Maxwell Armstrong, (Saskatchewan '29) formerly located at 3590 St. Famille St., Montreal, is now located at 11 St. Francis St., Ottawa. Mr. Armstrong is in the Division of Forage Crops, Central Experimental Farm, Ottawa.

B. B. Strachan, (Manitoba '29) Field Representative for the Pacific Wool Growers, is located at 461 Davis St., Portland, Ore.

H. J. Siemens (Manitoba '25) has changed his house address to 542 Sixteenth St., Brandon, Man.

C. R. Healy (McGill '31) is now located at Edifice Premier, 33a King St. West, Sherbrooke, P.Q.

E. E. Carncross, (Toronto '16) formerly with the Soldier Settlement Board, now owns and operates the Western Peat Company of New Westminster, B.C., and sells peat dried and processed for a variety of purposes. His address is 1485 Douglas Road, New Westminster, B.C.

R. W. Stuckey (McGill '28) is now located at the Agricultural Department, Kampala, Uganda, B.E.A.

J. de Broin, (Paris '24) formerly with the Western Canada Flours Mills in Montreal, is now operating a hatchery and broiler plant known as the Terrebonne Poultry Corporation at Terrebonne, P.Q.

A. Besner, (Montreal '23) formerly at Gaspé, is now Assistant Agronome located at 261 Blvd. Monkland, St. Laurent, Montreal, P.Q.

J. H. Bruneau, (Montreal '28), formerly County Agriculturist at Lac Mégantic, P.Q., is now located at 18a rue Laurier, Sherbrooke, P.Q.

Norman Criddle

1876 - 1933

The passing of Norman Criddle of Treesbank, Manitoba, brought to a close the career of one of the pioneers in technical agriculture in Canada. Coming to Canada with his parents in 1882 he was brought up on the farm in Manitoba. He developed his talents as a naturalist and artist, and in 1905 and 1908 illustrated the Dominion Weed Book, and Pasture and Fodder Plants, two standard publications that are familiar to all who have gone through our Canadian agricultural colleges.

In 1910 he came to Ottawa and joined the Dominion Seed Branch, later transferring to the Entomological Branch. He was in charge of the work of this branch in Manitoba from 1914 until his death. He became the outstanding authority on grasshopper control. His interests in science were wide, as attested by his list of publications including 63 papers on entomology, 32 on bird life, 9 on mammals and 10 on plants.

His death came at a time when honor had just been done to him. The Manitoba Agricultural College, in recognition of his scientific work, had just awarded him an honorary degree. He was a member of many scientific societies. As Chairman of the International Great Plains Crop Pest Committee, Mr. Criddle was preparing for a meeting of this organization at the World's Grain Exhibition and Conference. A paper he had written, giving the summary of years of work in connection with grasshoppers, will be read by one of his colleagues.

Mr. Criddle was unmarried and leaves to mourn three brothers and three sisters, all of Treesbank, Manitoba. His fellow workers in his own field feel his loss deeply, and those who had only occasional contact with him will miss the breadth of knowledge and kindly personality that made it a pleasure to work with him.

WORLD'S GRAIN CONFERENCE AND C.S.T.A. PROGRAMME

Plans for the sessions of the C. S. G. A., the C. S. T. A., and technical groups are sufficiently advanced to permit the issuing of a statement regarding the tentative programmes. The arrangement of the various programmes to secure as much co-ordination as possible is in the hands of the Programme Committee of the World's Grain Exhibition and Conference of which Dr. E. S. Archibald is Chairman and Mr. H. L. Trueman is Secretary. While all technical groups are being consulted as to the detail of arrangements for their group sessions, the final dovetailing of these sessions rests with the Programme Committee of the Grain Conference.

The Canadian Seed Growers' Association is meeting on Friday and Saturday, July 21 and 22, previous to the opening of the Grain Show. The programme of this meeting is entirely in the hands of the C. S. G. A. officials. It is anticipated that members of this organization will remain for many of the technical sessions to be conducted during the next two weeks, especially the sessions which will be held by the Western Canadian Society of Agronomy.

The Canadian Society of Technical Agriculturists is holding a business session on Monday, July 24th, and will endeavour to clean up all the C. S. T. A. business during this session. On Monday evening the C. S. T. A. plans to throw open to the public an illustrated lecture by Mr. E. J. Stirnaman, Consulting Engineer of Brooklyn, Iowa, on the "Mechanization of Agriculture in Russia." Mr. Stirnaman spent several years in Russia and has a wealth of material on this subject.

The World's Grain Exhibition and Conference will be officially opened on Tuesday morning, July 25th. There will be morning sessions of the Conference from Tuesday to Friday of the first week and from Monday to Wednesday of the second week. These sessions will deal with the marketing, distribution, financing, and consumption of grain. Outstanding speakers from several countries will represent the various interests involved. It is expected that these sessions will produce a compendium of information on the complex problem of world grain movements. These sessions will be held in the armouries located near the World's Grain Exhibition Building and in the Regina Exhibition Grounds.

Afternoon sessions of the World's Grain Conference will be joint sessions with various technical societies and groups of the C. S. T. A. Several of these sessions will run concurrently and an effort will be made to avoid over-lapping of interest as far as possible. Sessions will be held in Regina College and adjoining buildings. While it is not yet possible to give a complete list of speakers, some indication of the subjects for the sessions can be given.

The Western Canadian Society of Agronomy will have charge of the sessions on agronomy and will meet during the first week of the Grain Conference and possibly for part of the second week. The session on cereal breeding will include such subjects as improvement of wheat varieties, the meaning of genetics for plant breeding, and the relation of the bio-chemist to cereal breeding. The session on forage crops will cover winter hardiness, breeding alfalfa and sweet clover, breeding pasture grasses, world trade in herbage seeds, development of the soy-bean in Canada and the distribution of forage crops in western Canada. There will also be a session on Experimental methods taking into account field plot technique, field plot machinery, co-operative grain research in Western Canada and the organization of milling and baking research. Cultural problems including machinery, rotations, weed control and insect pests will be discussed in conjunction with other groups. In connection with the Soils Group, an interesting programme on soil drifting and soil moisture is being built up. A joint session of the Agronomy Society, Soils Group and the Cereal Chemists will be held on fertilizers, and outstanding speakers include Dr. E. Truog of Wisconsin, Sir John Russell of Rothamstead, Professor S. A. Waksman, of New Jersey, Professor P. L. Gainey of Kansas and Dr. F. C. Bear of New York.

The Canadian Phytopathological Society is planning a programme on plant diseases. Among the speakers who are expected to be present are Dr. J. A. Clark and Dr. J. B. Humphrey of the Bureau of Plant Industry, Washington. The Cereal Chemists will hold sessions discussing the influence of environment on wheat quality, the malting qualities of barley, quality of soft spring wheats, evaluation of durum wheats, milling and baking qualities of wheat from various parts of the world, and relation of harvesting methods to wheat quality. The Agricultural Engineering Group of the C. S. T. A. is arranging a programme covering the following subjects: economic effect of mechanization in wheat production, economic use of power in large and small units, combine harvester investigations, mechanization of agriculture in Russia, and new types of farm machinery used in grain growing sections. The Soils Group, in addition to co-operating with the Western Canadian Society of Agronomy, will have a series of papers on Canadian soil work. The Canadian Society of Agricultural Economics is planning a joint session with the Engineering Group on the economic effect of farm machinery and with the live stock men on live stock problems. They will also have a session on wheat production in various parts of the world and a session including a discussion of farm tenancy in western Canada, and other related subjects.

During the second week the Western Section of the Canadian Society of Animal Production will hold its annual meeting. Sessions are planned on the range production of cattle and the marketing of grain through the live stock route. There will also be special papers on contagious abortion, the economic status of the horse industry in western Canada, the place of live stock research, and several committee reports representing the work of standing committees of the society. The session on marketing grain through the live stock route will be an open session of the Grain Conference and will be held on Thursday afternoon, August 3rd. The Great Plains Section of the International Crop Pest Committee plans to hold its annual meeting in Regina. Four sessions will be held on various insect pests affecting grain crops. Speakers will be present from the United States Department of Agriculture and various State Institutions.

At the present moment it is impossible to say on just what days these various sessions will be run, but it is generally agreed that as many sessions as possible will run during the week of July 24th and anyone planning to spend that week in Regina can be assured of a full and interesting programme. On Saturday, July 29th, a trip is planned to the Dominion Experimental Farm at Indian Head where samples of the grain on exhibition will be seen under growing tests. No evening technical programmes have been planned as it is desired to keep evenings free for entertainment and for such special committees as the various groups may find necessary.

NEW MEMBERS

The following applications for regular membership have been received since March 1st, 1933:

- D. A. Bell (Toronto 1931, B.S.A.), Barrie, Ont.
- P. E. Bernier (Laval 1933, B.S.A.), Ste. Anne de la Pocatière, P.Q.
- P. Chepeswick (Toronto 1932, B.S.A.), Ottawa, Ont.
- H. W. Goble (Toronto 1931, B.S.A.), Ames, Iowa.
- H. J. Hargrave (Alberta 1932, B.Sc.), Medicine Hat, Alta.
- A. W. Jones (Toronto 1932, B.S.A.), Ottawa, Ont.
- J. A. Kavanagh (Laval 1924, B.S.A.), Ottawa, Ont.
- R. E. Neidig (Iowa 1915, Ph.C.), Calgary, Alta.
- E. G. Paige (McGill 1929, B.S.A.), Ottawa, Ont.
- I. W. Parnell (Cambridge 1932, Ph.D.), Macdonald College, P.Q.